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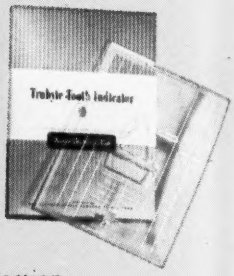

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Emil H. Bollwerk, D.D.S.

1905-1952

Dedication

EMIL H. BOLLWERK

1905-1952

THIS issue of The JOURNAL OF PROSTHETIC DENTISTRY is dedicated to the living memory of Emil H. Bollwerk, colleague and friend, who served until the time of his death as an Associate Editor of this JOURNAL.

Those of us who were privileged to know and to work with Emil Bollwerk recognized him as a man who sought no recognition, but who cheerfully accepted any task and gave to it his ablest efforts. His devotion to his profession is evidenced in his loyal service to organized dentistry.

Doctor Emil Bollwerk graduated from St. Louis University School of Dentistry in 1927. His interests and achievements in dentistry soon became apparent, and honors began coming to him. In 1938, he was elected to membership in Omicron Kappa Upsilon, honorary dental fraternity; in 1947, he was made a Fellow of the International College of Dentists, and in 1950, he was made an honorary member of the Milwaukee Dental Forum. He served dentistry in many ways. He was Chairman of the Veterans' Welfare Committee of the St. Louis Dental Society, a member of the Study Club Board of the St. Louis Dental Society, the Secretary-Treasurer of the Council of Auxiliaries of Delta Sigma Delta Fraternity, the Secretary and later the President of National Dental Veterans League, Chairman of the Program Committee of the St. Louis Dental Society, President of the St. Louis Society of Dental Science, a member of the Fédération Dentaire Internationale, a member of the Executive Council of the Missouri State Dental Association, an Associate Editor of the Journal of the Missouri State Dental Association, the Chairman of the American Dental Golf Association Local Arrangements Committee, and member of the Executive Council of the American Dental Golf Association, a member of the Council on Federal Dental Services of the American Dental Association, a member of the National Advisory Committee of America's Dental Leaders.

He gave freely of his time and knowledge by giving numerous clinics and lectures, and by participating in round table discussions before many groups and in many parts of the country.

His record in the service of his country was outstanding. His insistance on high quality dental care for the officers and men treated by him and those under his command brought commendation and further responsibilities to him. He served

in the armed forces from 1942 to 1946, and was promoted to the rank of Lieutenant Colonel in the Dental Corps Reserve.

He served the American Denture Society in many ways. He was a member of the Executive Council, a member of the Program Committee and Chairman of the Publications Committee.

As Chairman of the Publications Committee of the American Denture Society, he was a leader in the organization of the Editorial Council of THE JOURNAL OF PROSTHETIC DENTISTRY. He served the Editorial Council as its Secretary, and the Journal as the Associate Editor representing the American Denture Society.

It is our thought that this JOURNAL, to which Doctor Emil H. Bollwerk contributed so much, by this dedication can most fittingly record our tribute to him. He shared with us the vision of a comprehensive journal on prosthetic dentistry; he labored tirelessly toward its realization. His sober judgment in the management of JOURNAL affairs, and his constant efforts to secure material for the JOURNAL have done much to make it possible. His memory will be an inspiration to those who would serve dentistry.

—Carl O. Boucher.

THE JOURNAL OF PROSTHETIC DENTISTRY

Vol. 3 March, 1953 No. 2

THROUGH THE EYES OF THE EDITOR

LaMar W. Harris suggests the use of a soft plastic liner in acrylic impression trays to make stabilized baseplates. This technique saves the time required for making a second "hard" base, and provides elasticity which permits a more perfect adaptation of the liner to the cast than is possible with "hard" liners.

George T. Perkins describes a technique for the arrangement of teeth by a symmetrical setup. He states that this symmetrical arrangement of teeth will provide an equalization of pressure. We wonder if Nature produces so precise a symmetry in the growth and development of the jaws. Natural anterior teeth often have an asymmetrical symmetry, and often the mesial proximal contact of the upper central incisor teeth does not coincide with that of the lower incisor teeth. The arrangement of the anterior teeth should be such as to produce the *effect* of the twelve anterior teeth (as a unit) being centered in the face even though it may be an *illusion*. His suggestions regarding the orientation of the occlusal plane seem sound, and his specifications for the buccolingual position of the posterior teeth are excellent. The use of the curved template for establishing the compensating curve may be satisfactory for the average patient, but for patients whose condyle paths are not average, some modification is required.

G. H. Spicer describes a very simple technique for recording hyperplastic ridge tissues in an impression without distortion. While the procedure is not new, it will do a difficult job well.

Arthur Van Victor suggests the use of custom made acrylic teeth for immediate dentures. The technique he suggests makes possible an exact reproduction of the form and arrangement of the teeth. The plastic teeth are made from molds which are made from casts of the natural teeth. The procedure permits more than one set of teeth to be made from the original mold. This avoids difficulties when duplication is necessary. He suggests the use of immediate dentures without labial flanges in certain situations. It should be pointed out that this type of restoration should be used for a comparatively short time since the ridges do shrink and allow the lip to be unsupported.

LaMar W. Harris makes a preliminary report on immediate permanent relines from a practical rather than a testing or research viewpoint. He points out that his observations are clinical in nature and that a final evaluation of the materials cannot be made for several years. He describes the technique which he has found to be best within the time he has been using the materials.

H. W. Tustison describes a simple and practical technique for placing gold inlays in porcelain teeth. He suggests that a stock of these teeth with fillings be prepared so they may be used when they are indicated for esthetics.

Francis J. Moylan presents a different philosophy of occlusion from those which

are commonly accepted. He divides the closing action of the mandible in the chewing cycle into two phases. The first is a hinge motion around the condyles, and the second is a reverse rotation around the contacts between the upper and lower bicuspid teeth which continues until the condyles are braced against the articulating eminences of the glenoid fossae. His interpretation of jaw movement is undoubtedly influenced by the results of registrations made by his recording device, since the bearing point of the device is placed anteriorly to the geometric center of the bearing areas of the jaws, and since the registrations are made while closing pressures are being exerted upon the bearing point. Registrations produced under these conditions would produce cast relations which would develop the first tooth contacts in the anterior part of the occlusion when the dentures were placed in the mouth. Posterior tooth contacts could be developed only when corresponding amounts of pressure would produce the same amount of tissue displacement as existed at the time the registrations were made. The suggestion that the "time" of contraction of the closing muscles of mastication is a means for determining the vertical dimension of occlusion may have some value and is certainly worth additional study.

Meyer M. Silverman reports further on the technique and results of the speaking method of measuring vertical dimension. The method makes use of the physiologic action of muscles during the production of certain speech sounds. His observations indicate that these actions are constant throughout life and are therefore a guide in the determination of vertical dimension. The absence of permanent landmarks after all teeth are lost seems to be a handicap to the use of this method, although the artificial teeth can be used in the same manner as the natural teeth while they are being arranged.

V. E. Ireland has discussed the annoying problem of the clicking jaw in such a way as to make an understanding of it possible. He has classified the patients with "clicking jaws" into groups according to the symptoms. On the basis of this classification, he discusses the mechanism of clicking in a logical manner. The treatment he suggests for each type seems sound and worthy of study.

Victor O. Lucia bases his discussion of the fundamentals of oral physiology and their practical applications on four assumptions. This is an excellent method for preventing confusion for, whether or not one agrees with the assumptions, the scope of the discussion is limited to the discussion at hand. He believes that a hinge axis mounting is essential for an analysis of jaw relation records and articulator adjustments and for their interpretation in the occlusion. This is correct except for certain articulators (Stansbery Tripod) which record positional relations without an attempt to reproduce the possible intermediate relations. He separates the consideration of centric relation and centric occlusion but emphasizes the importance of making the centric occlusion occur when the jaws are in centric relation. If centric relation is recorded incorrectly, all other jaw relations will necessarily be incorrect. The centric occlusion will be likewise incorrect when the dentures are placed in the mouth. His analysis of the importance of the condyle path to occlusion on the balancing side is sound. The consideration of the effects of the variations in the Bennett movement and the explanation of the Bennett movement are the clearest we have seen. However, his recommended procedure for adjusting the Hanau Model 'H' articulator by means of *lateral* as well as protrusive checkbite is unworkable. The Hanau Model 'H' articulator will not accept lateral checkbites accurately because it does not have a variable intercondylar distance and because of the variations he suggested in his discussion of the Bennett movement. He correctly emphasizes the importance of treating the chewing mechanism as a complete unit rather than as a series of operations on its parts.

Herman C. Levitch has described the construction of a "stress-equalizer" for partial dentures. It is a simple and effective device which is easily made as a part of a one piece casting. It has the advantage of relieving the clasped teeth of occlusal stress while at the same time it provides resistance to lateral forces.

William R. Joule urges cooperation between the various specialties in dentistry. He points out the places where orthodontists can assist the work of prosthetists by making or closing spaces which are troublesome to fill by restorations. Adult orthodontia has been overlooked to a great extent by the profession. It can be used successfully for many patients to simplify the eventual restorative problem.

Alexander Leff has described a simple technique for making a temporary acrylic bridge. It makes use of the paint-on method for handling the "cold" curing acrylics. The material is "painted" into an alginate impression of the teeth to be restored. It seems to be a simple, effective procedure.

Edwin H. Getz has adapted the hydrocolloid impression materials to the problem of recording interocclusal relations by means of a checkbite-impression tray. While there are advantages to the method, caution should be observed in its use. If the centric occlusion of the teeth coincides with centric relation, the procedure can work well. If the unrestored occlusion is permitted to guide the jaw into an incorrect position, the recorded jaw and tooth relations will be incorrect. This can be avoided by proper guidance and control of the patient. The technique opens up many channels for research.

Gerald D. Stibbs emphasizes the importance of accuracy in all phases of gold inlay procedure. Each step is analyzed and the factors which may cause failure are pointed out. The result is a description of procedures that are sound yet simple and time saving. We are remined that all of dentistry requires infinite attention to detail.

John T. Lindquist, Ralph E. Brennan, and Ralph W. Phillips have reported tests on artificial stones mixed by various methods. Their results confirm the value of mechanical spatulation and vacuum mixing.

I. Franklin Miller has written a fine book review of "The Porcelain Jacket Crown" by S. Charles Brecker. He calls especial attention to the new approaches to the problems of restoring teeth in unusual conditions or situations. The classification of these situations in the book is the most complete we have seen.

This is the first of a series of book reviews which are planned for the JOURNAL. Others will appear from time to time as they are prepared.

—Carl O. Boucher

AN ADVANCED USE FOR IMPRESSION TRAYS

LaMar W. Harris, D.D.S.

Chicago, Ill.

THE SUCCESSFUL denture is the goal toward which we are constantly striving, and while we cannot say that any one point alone insures that success, we do know that any one point can hold the key to failure.

It has been most illuminating in the work in the plastic field to find how many steps in denture work have been aided or simplified by the adaptation of one or more of the dental plastics. The study casts and face masks are an integral part of the diagnosis, and the individual impression trays have done a great deal to give us greater accuracy in the preparation of casts[1].

The stabilized tray is the next step with which we are concerned, as both vertical dimension and centric relation depend upon properly fitted bases. Pyott and Schaeffer[2] say: "With the bite rims seated firmly . . . . vertical dimension is so closely allied with that of centric occlusion that the former cannot be determined without considering the latter."

The stabilized trays outlined in a past presentation[1] were a vast improvement over anything we had known before, but were still not designed to compensate for the undercuts to be found in the average cast.

It is one of the purposes of this paper to describe a method of making properly fitted stabilized trays to aid in the establishment of both vertical dimension and centric relation with the minimum of work. This new method of adaptation so well seats the baseplates that the patient is sufficiently comfortable as to give a relaxed and accurate registration. Articles in the literature stress the need for a relaxed position of the mandible when the vertical dimension is determined and when either intraoral or extraoral tracings are made for establishing centric relation. The shellac baseplates with or without pastes were at best lacking in comfort, consequently the patient was quite likely to give an abnormal registration merely because he was trying to avoid a sharp point or an uncomfortable edge.

The development of a soft liner to be used as part of the baseplate eliminates all need for pastes, and assures comfort at all times. The work of both patient and dentist is thereby aided. The material used is similar to some of the impression plastics now on the market. It is a combination of vinyl and acrylic resins with alcohols and plasticizers which give it a very short chemical cycle. In about five minutes after mixing it arrives at a definite elastomer state with sufficient elastic qualities to permit it to spring over deep undercuts and again assume its original shape. The material feels similar to velum rubber.

Read before the American Denture Society in St. Louis, Mo., Sept. 5, 1952.
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TECHNIQUE

The baseplate is prepared by lining the individual acrylic impression tray with a soft plastic. This eliminates the necessity for making a second hard base for use as a baseplate. The impression tray is prepared in the usual manner.[1,3] One sheet of pink wax is adapted over the cast made from the primary impression. The activated acrylic resin is adapted over the wax by finger pressure. The thickness of the wax will provide sufficient space for the impression material.

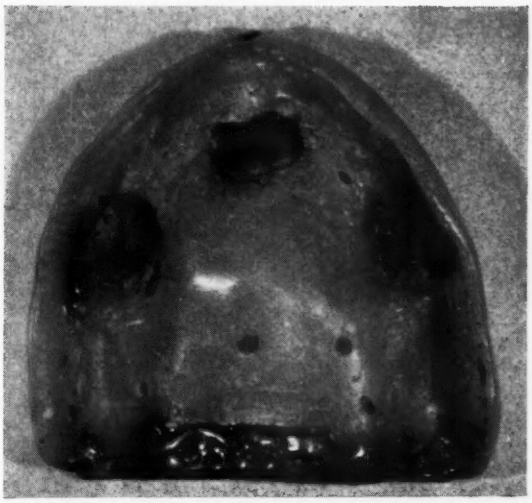

Fig. 1.—A prepared tray ready to receive the impression material for the permanent impression.

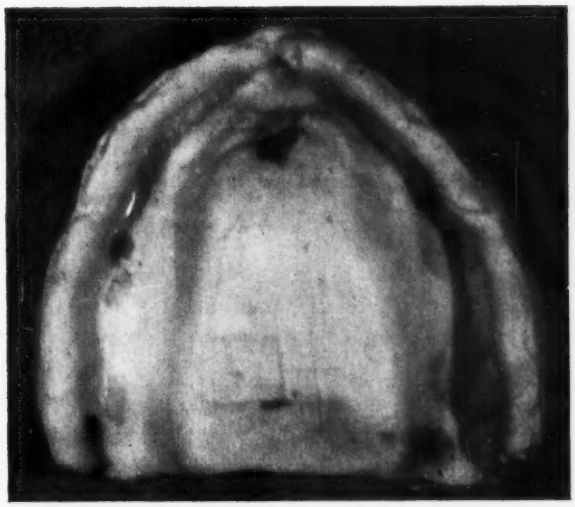

Fig. 2.—A permanent impression with four points of modeling plastic showing through.

The tray thus formed is carefully trimmed at the periphery and holes the size of a No. 8 round bur are drilled through the palate and the flanges to retain the impression material. Modeling plastic (or compound, as it is erroneously called) is placed at four places in the tray. These are at the rugae area, the molar ridge areas on each side, and at the carefully located postdam area (Fig. 1). The impression can be made with the impression material of choice (Fig. 2), and the master cast is poured.

After the master cast has been prepared, carefully remove all impression material and preserve the impression tray. Cleanse it thoroughly of all impression material and modeling plastic, then wipe it with a mastic or similar material to

Fig. 3.—The material measured for mixing, and the mastic being applied to the tray.

give it a slightly tacky surface on the basal seat (tissue) side (Fig. 3). The only soft plastic available at this time for lining the tray is Tray-Stay. Tray-Stay is mixed according to the directions of the manufacturer (two parts powder to one of liquid) and added quickly to the periphery of the cast, and to the tacky impression tray while the material is quite soft (Fig. 4). A sufficient amount of the material will flow onto the palatal area of an upper tray to make an accurate base without too much bulk. It will flow so as to extend from the periphery of the lower tray to the ridge area. The lining should be of limited bulk so that a seal is perfected but without creating a cushion. About three minutes working time is available from the time of the combination of the powder and liquid to the

time at which it may be easily applied to the cast. Allow the lining material to set about five minutes in water at approximately 135° to 150° F. This water temperature is normally available through a hot water faucet. Remove the lined baseplate from the cast, trim it, and it is ready for immediate use. Test work has proved the material to be of very good dimensional accuracy, particularly if the dentures are finished in a reasonable length of time. On initial set the material shows no discernible expansion or contraction when tested in glass cylinders.

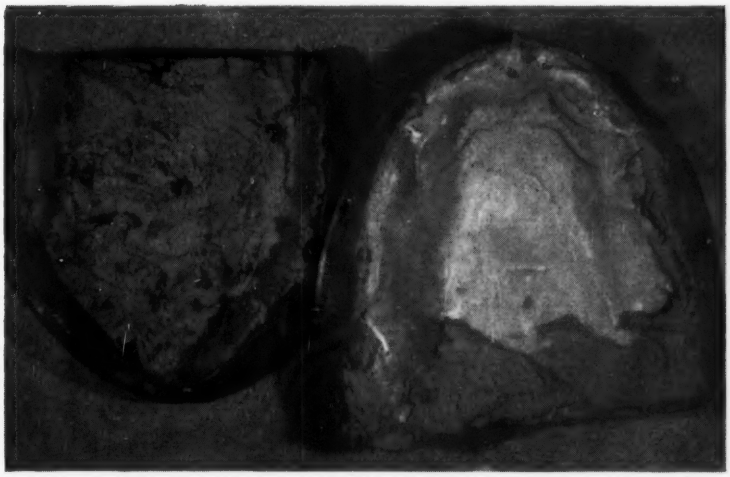

Fig. 4.—Trav-Stay painted on periphery of a cast and on the tray.

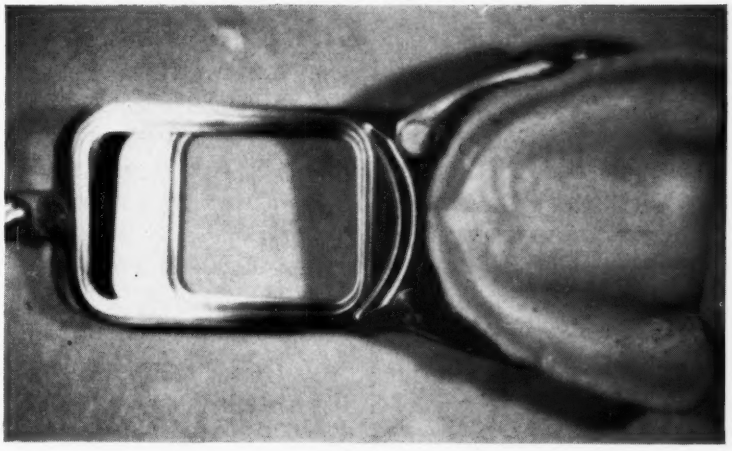

Fig. 5.—The equipment placed on finished baseplates for an extraoral tracing.

Wax may then be added to the lined bases for the determination of vertical dimension, and the equipment placed later for the intraoral or extraoral tracings (Fig. 5). Since the plastic remains pliable for weeks, the bases will continue to fit both mouth and cast for the entire time normally consumed in the making of dentures.

The slight banana oil taste evidenced by the material is not unpleasant, and the feel of the base and its adhesive qualities are spoken of as a pleasant part of the denture procedure. Not only is one step eliminated, but greater accuracy is insured. We may add one more dental plastic to our ever-growing list.

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EQUALIZATION OF PRESSURE BY SYMMETRICAL SETUP

COLONEL GEORGE T. PERKINS, Dental Corps, United States Army

Percy Jones Army Hospital, Battle Creek, Mich.

WHAT a pleasure it is to know that at least the thesis of this paper is agreed to and accepted by all prosthodontists. They may disagree violently with the approach to and the solution of it, but if I am successful in luring them into the meat of the subject—perhaps they will try it!

There have been many concepts introduced to the profession concerning the setting up of teeth, with each school of thought having its own particular method. These may involve setting the teeth on a flat plane, reverse curve, or by developing the compensating or curve of occlusion; all these techniques are striving for the same end result—centric occlusion and balance—yet they are generally different in technique. Strangely enough, each advocate can produce evidence to support his findings, yet their agreement on what type of tooth and method of alignment to accept is not foreseen in the immediate future. They do, however, agree on one point, "equalization of pressures," and it is this point that will be developed by a symmetrical set-up.

In developing this technique, all of the lower teeth are set up first, with the exception of the two upper central incisors. Why? Because the lower base is, by its very anatomy, the most unstable. Therefore, we must concentrate on it, using accepted principles of engineering—particularly the influence of inclined planes and leverages—to enhance its stability. That these principles are involved in the functioning of teeth, jaws, and supporting structures is elementary, yet probably only slightly considered by many. These two factors modify, transmit, and direct lines of forces during the chewing cycle and should be thoroughly understood. Since a detailed explanation is not intended in this paper, the reader is directed to the work of Sears[1]. Suffice it to say that our immediate problem then becomes the correction of unfavorable inclined planes and the control of unstabilizing leverages. However, in spite of sound planning, we have movable tissue upon which to construct our denture and the good engineering principles do not *all* apply until maximum force is exerted. Therefore, dentures built with these principles in mind reach their greatest stability (effectiveness) when maximum masticatory pressure is exerted.

To begin the set-up, we shall assume that the casts have been mounted on an adjustable articulator, and all registrations have been recorded. Orientation of the mounting must then be made in three dimensions to evaluate properly the edentulous areas; (1) the frontal aspect (Fig. 1) to establish whether or not the

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The opinions or assertions contained herein are the private ones of the writer and are not to be construed as official or reflecting the views of the Army Dental Corps.

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maxilla is in normal relationship to the mandible or whether a crossbite exists, (2) the sagittal view (Fig. 2) to determine this relationship of the upper arch in respect to the lower. In the ideal or normal, the basal seats are parallel and the anterior labial limit of the upper arch is directly above the lower. Should a horizontal overlap exist, the anterior labial limit of the upper arch would naturally extend beyond the crest of the lower ridge. (3) The horizontal view of the lower arch is of utmost importance in this technique, as it plays a role that is definitely set by anatomic landmarks (Fig. 3); in order of importance, they are the crest of the ridge, the mylohyoid ridge, and the retromolar pads.

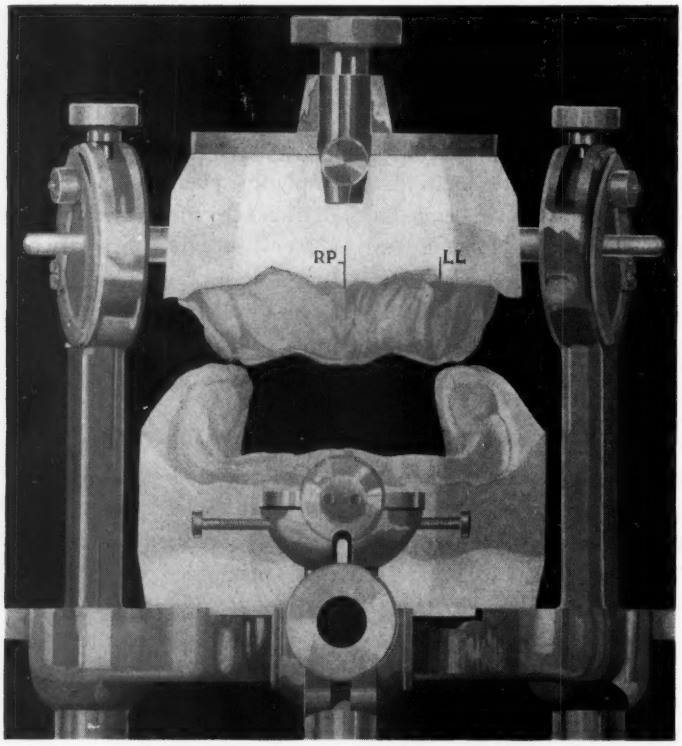

Fig. 1.—Frontal view of mounting showing a normal relationship with RP (reference point) on the midline and the low lip line measurement taken from the upper occlusal wax plane.

To define and inscribe these landmarks as a permanent record on the lower cast, a straight edge is used to locate points *A*, *B* and *L*. This is accomplished by placing a straight edge along the crest of the ridge on the cast, and where it terminates anteriorly and posteriorly marks the *A*-*B* limits. Then, using point *A* as the axis, the *A*-*L* limit is determined by swinging the straight edge toward the lingual until it is above and parallel with the mylohyoid ridge. Thus is formed the anterior limit *A*, posterior *B*-uccal, and *L*-ingual limits of an imaginary triangle. This imaginary triangle created by points *A*, *B*, and *L* is that distance or arc to which we are at liberty to move the posterior teeth buccolingually in order to

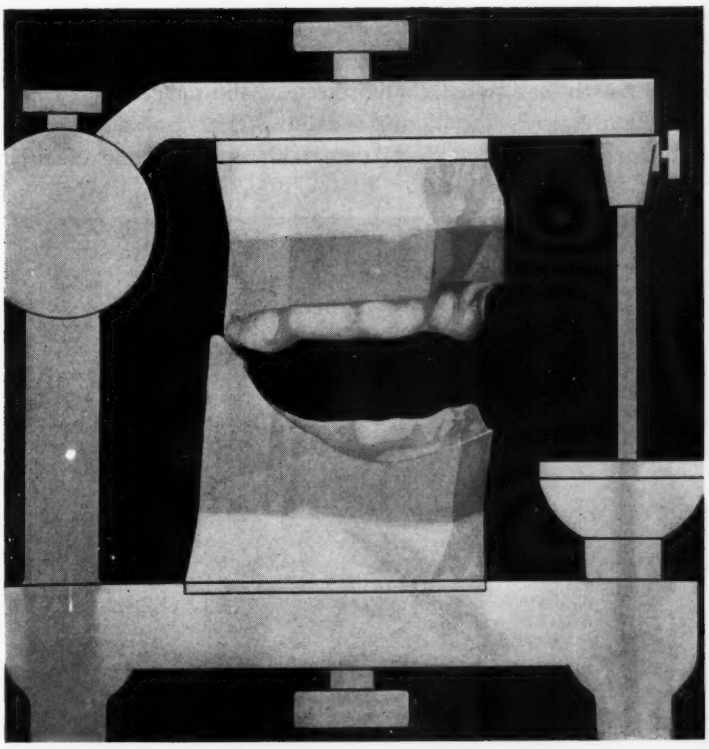

Fig. 2.—Sagittal view—normal relationship, basal seats are parallel and no horizontal overlap.

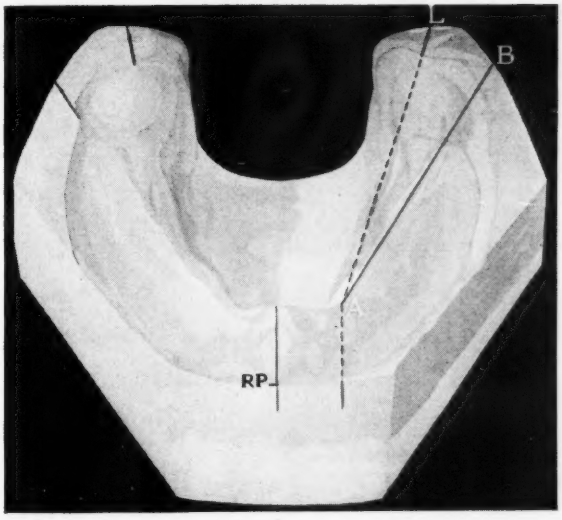

Fig. 3.—Horizontal view—line *A-B* defines the crest of the ridge, while *A-L* determines the lingual limits of the mylohyoid ridge.

accommodate the upper arch without sacrificing stability. That is, the more lingually we are able to set the posterior teeth (not beyond the mylohyoid ridge), the greater the stability. Conversely, the more buccally beyond the *A, B* line, the greater the instability. Kurth[2] has stated, "The selection and positioning of posterior teeth is a most important consideration," and the above criteria should never be violated. Since the anterior limit of one side of the arch has been determined, the opposite

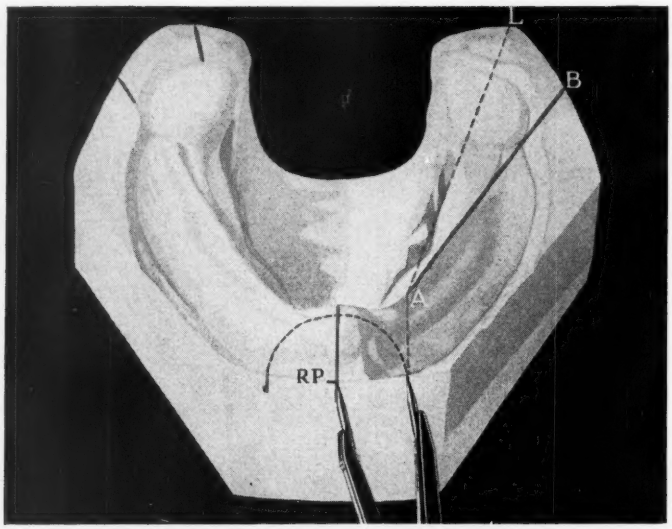

Fig. 4.—Application of the dividers. Both "*A*" limits are equidistant from midline.

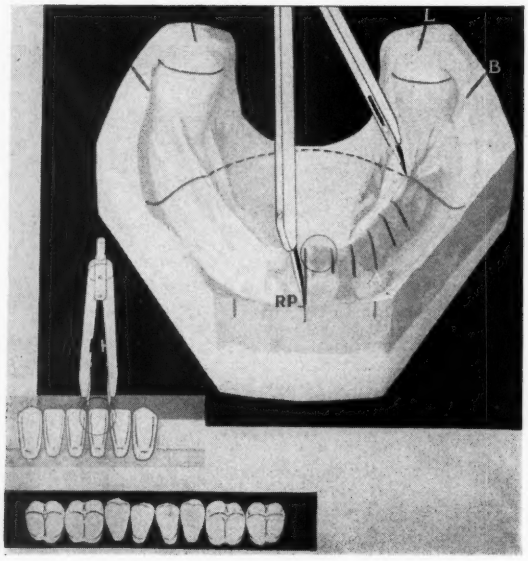

Fig. 5.—Predetermined location of each tooth on one side and the crest of the retromolar pads completed. The dividers locate the distal of the opposite first molar.

A limit is located by the aid of dividers, measuring from the reference point on the midline, and swinging to the contralateral (Fig. 4). We now have both anterior limits equidistant from the midline. Interestingly enough, experience has shown that the anterior limits pass through the crest of contour of the lower cuspids.

After carefully selecting the teeth, we next predetermine the location of each tooth on the crest of the ridge by actual measurement (Fig. 5). This includes all

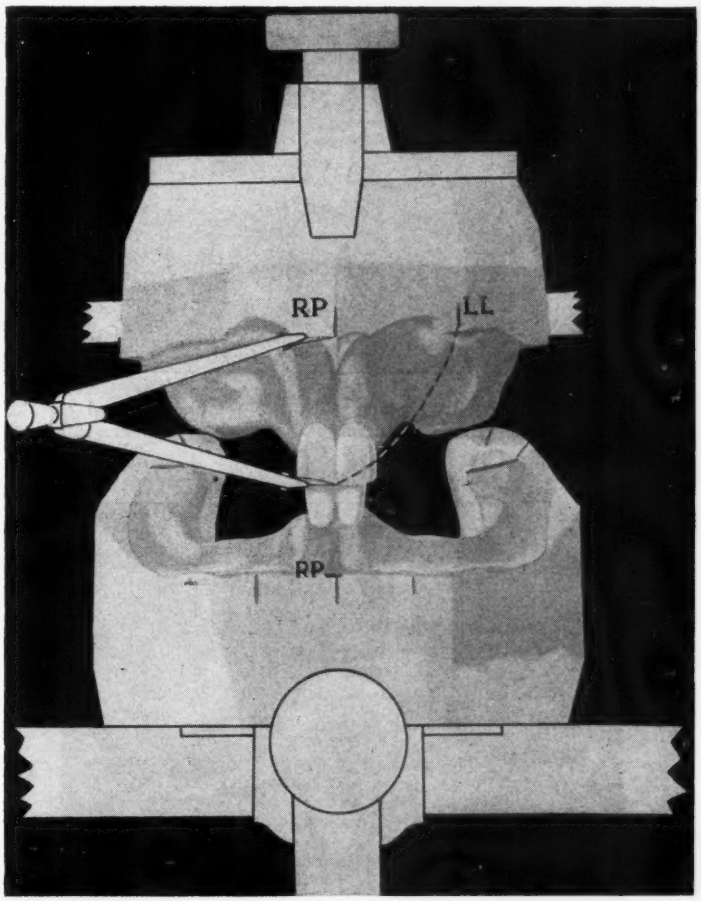

Fig. 6.—Checking the low lip line of the upper central incisors with dividers from the *R P* and enscribed measurement made at the time vertical dimension was determined.

teeth on one side back to and including the distal of the first molar. To locate the opposite first molar, measure from the reference point on the midline and swing to the opposing ridge. Both first molars are now equidistant from the midline. Complete the marking of the lower cast by marking the crest of the retromolar pads with a semicircle, which is shortly to become one point in the orientation of the occlusal plane.

Pink baseplate wax is adapted to the edentulous areas and luted to the casts. The setting of the six key teeth follows; the upper central incisors are waxed into position first and checked with dividers for the correct length (Fig. 6). The lower central incisors follow, and care should be exercised in making certain that the midlines of the upper and lower central incisors coincide. (Check yourself by observing the midline from the rear.) The occlusal plane is then oriented by placing

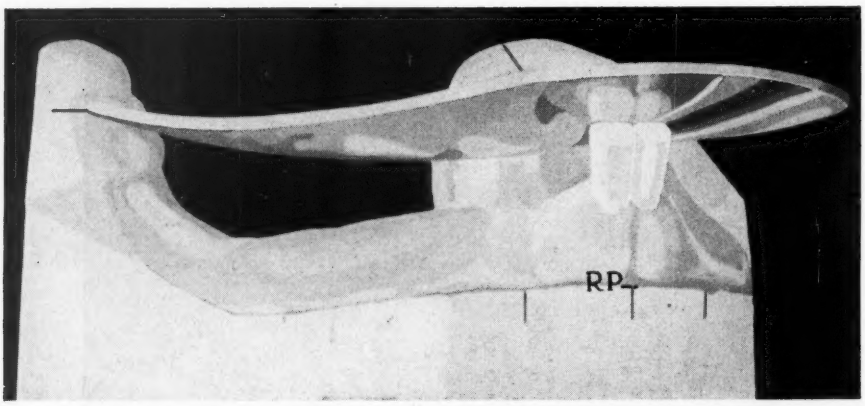

Fig. 7.—Orientation of the occlusal plane with the template placed on the crest of the retromolar pads and the incisal edge of central incisors. The mid line of the template must be in harmony with the teeth.

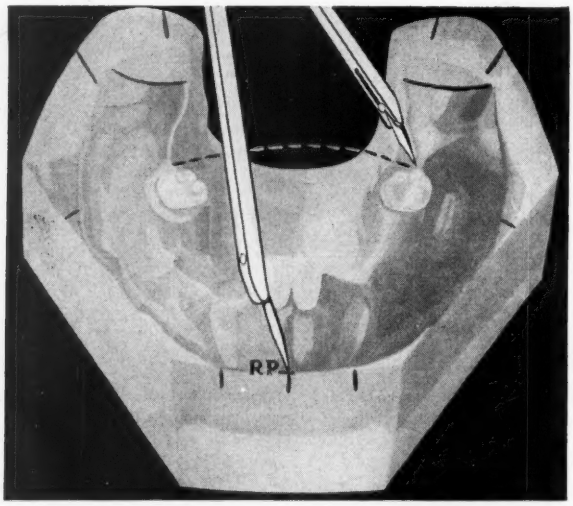

Fig. 8.—Checking equidistance by arching from the distobuccal cusp of the first molar to the opposite counterpart.

a template, a segment of an eight-inch sphere, on the line marking the crest of the pads and the incisal edge of the lower central incisors (Fig. 7). The first molars are now placed in their predetermined locations, which can easily be seen through the wax (Fig. 8). Position them buccolingually, using the imaginary triangle to accommodate the upper arch and check from time to time with dividers to main-

tain both teeth equidistant from the midline. All lower teeth from now on must engage the template, for it is by this means the compensating curve of occlusion is developed (Fig. 9). If care has been exercised in setting the key teeth, the remaining teeth will fall into position without effort, and your success will depend upon the constant use of dividers to maintain equidistance from the reference point. It should be remembered, however, that after the dentures have been processed, milled, ground and finished, the template is of no significance, as condylar inclinations have by then exercised their influence in the final development. Now, since it is generally agreed that the center of the closing force is in the region of the first molar and second bicuspid, and both right and left sides are equidistant from the midline, both points opposite each other must have equal and positive pressure.

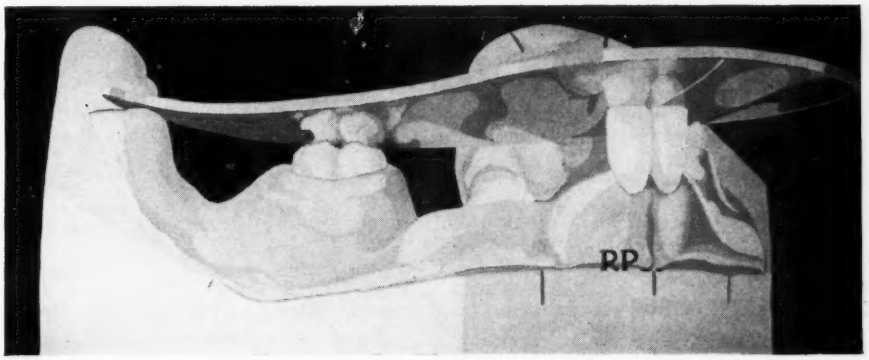

Fig. 9.—Key lower teeth in position engaging the template with the midline in harmony with that of the central incisors.

Kurth, Pleasure, and Stansbery all have conflicting methods of developing the curve of occlusion with equal success, and Moses[3] states, "At present I am undecided whether destruction of the ridges is greater in the Monson type of setup or in the anti-Monson type. We should place teeth so that the loading is axial or nearly axial in all positions, even during mastication." Using the technique described, I do know that in a period of four years and in the construction of over 960 dentures, we had only eleven failures. Suffice it to say that the ablest pronouncement came from Kurth[4] when he stated, "The occlusal plane of the posterior teeth can be set to follow any of the above technics, and be within the physiological limits of masticatory function if centric relation is accurately determined."

To incorporate esthetics, liberty may be taken with the upper and lower anterior, but with restrictions. For example, if an upper lateral is rotated and overlapped, the same must be followed with the contralateral tooth. What about cases with vertical and horizontal overlaps, might be asked. These conditions can be seen to exist when observing the mounting from the sagittal view. If the condition is extreme, they may be eliminated by shifting the posterior point of orientation of the occlusal plane from the crest of the retromolar pads to several millimeters below.

This will shift the posterior teeth down and forward and with the addition of a 3 to 5 degree anterior tilt of the lower incisors, practically all cases of extreme horizontal overlap may be compensated.

SUMMARY

1. Equalization of pressures is agreed upon by all, but the solution to the problem differs greatly.

2. The author has followed the described technique in order to accomplish equalization of pressures. (a) All lower teeth are set up first according to existing anatomy of the lower arch. (b) A thorough knowledge of the influence of inclined planes and leverages should be understood for correction and control of these unstabilizing factors. (c) Orientation of the mounting in three dimensions is necessary to properly evaluate the edentulous areas. (d) Predetermine the location of the lower teeth by measurement and thus maintain equidistance from the midline.

3. Nine hundred sixty dentures were constructed during a four-year period using this technique with only eleven failures.

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IMPRESSIONS OF RIDGES WITH HYPERPLASTIC TISSUE

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THE CONTROL of hyperplastic tissue during impression making has always been a problem. This tissue is so soft and so easily displaced that it is easily distorted. It is best to remove this tissue surgically, but this procedure is inadvisable for some patients. Other patients will not submit to the surgical removal of hyperplastic tissue.

A simple modification of standard impression procedures has been found to be effective for recording these hyperplastic ridge tissues without distortion.

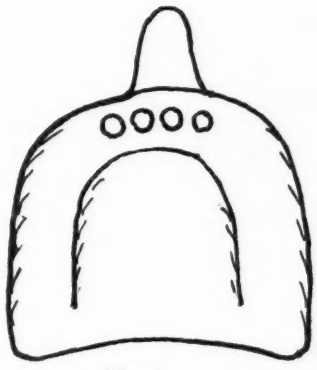

Fig. 1

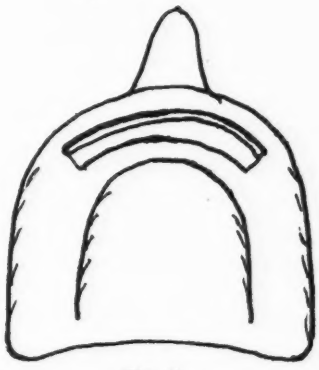

Fig. 2.

Fig. 1.—Holes are drilled through the baseplate tray over the area of the hyperplastic tissue before the zinc oxide and eugenol impression is made.

Fig. 2.—A slot is cut in the zinc oxide and eugenol impression and tray to expose the hyperplastic tissue.

A modeling compound impression is made in a stock tray. A cast is made in this preliminary impression. An oversized baseplate tray is formed over this cast and fitted to the mouth. Three or four holes are drilled with a No. 8 round bur through the tray in the area of the hyperplastic tissue (Fig. 1). An impression is made with a zinc oxide eugenol impression material in the usual manner.

A sharp knife is used to cut a slot out of this impression and the tray in the area of the hyperplastic tissue (Fig. 2). The slot should be large enough to allow the hyperplastic tissue to extend through it. The impression is reinserted in the

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mouth, and the hyperplastic tissue is worked down through the slot. This tissue should not contact the edges of the slot (Fig. 3).

A thin mix of Plastogum is painted on the exposed hyperplastic tissue extending through the impression with a small camel's hair brush (Fig. 4). The impression material is built up to contact the edges of the slot in the main impression (Fig. 5). Care is taken to avoid displacing the hyperplastic tissue. When the Plastogum has set, the impression is removed in one piece, and the cast is poured.

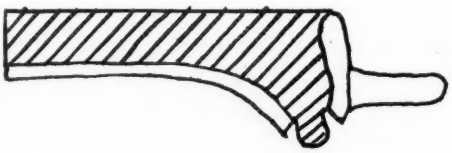

Fig. 3.—The prepared impression reseated in the mouth with the hyperplastic tissue exposed.

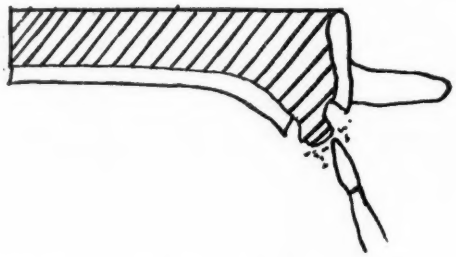

Fig. 4.—Plastogum is painted on the exposed hyperplastic tissue.

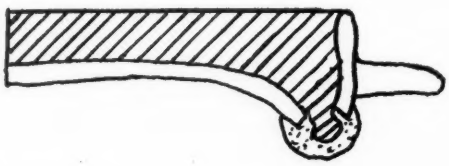

Fig. 5.—The completed impression.

This procedure will allow the hyperplastic tissue to occupy the space provided for it without distortion. Since the soft tissues are not displaced in the impression, they will not be displaced by the denture. The remainder of the denture will rest on a firm basal seat. The procedure may be modified for use on either arch or for relieving sharp ridges from pressure.

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POSITIVE DUPLICATION OF ANTERIOR TEETH FOR IMMEDIATE DENTURES

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MANY methods for the construction of immediate dentures have been presented, and the demand for this type of service is but small tribute to their continued use. The host of methods advocated have resolved themselves into a set pattern which is followed by many practitioners and with excellent results. However, the introduction of dental plastics in dentine and incisal shades has suggested changes in technique and is being used to accurately duplicate the anterior teeth. This, in combination with the socketing principle has resulted in another method which may be entirely acceptable but which deviates from the commonly accepted thinking. It is the feeling of the writer that no entire procedure can be applied universally, but can only include fundamentals that by reasonable application and experience produce the results originally intended.

The problems pertinent to immediate dentures are not necessarily those of full denture construction, and a realistic approach to these problems is essential. These limitations often recognized are ever present, and no paper could be complete without their appraisal. (1) The surgical procedures often present a poor base on which to place the immediate restoration. The ever-changing mucosa does not lend itself to a positive relationship between it and the denture. The fact that we must predict the outline of the ridge behooves us then to use materials that can be adjusted with ease. (2) The settling of these dentures, however slight, during the healing period often causes an imbalance in occlusal relationships with the attendant soreness and discomfort. (3) Many types of incisal relationships have to be duplicated in order to preserve the cosmetic effect consistent with the expectations of the patient. (4) Retention normally obtained with complete dentures is not often, if ever, achieved in this type of service.

Any carefully planned immediate denture procedure should result in an accurate duplication of the anterior teeth in order to preserve or improve the esthetics. Also, the change to the treatment denture should be expedited in such a manner as to produce a minimum of change in lip position and thickness. This change to the immediate denture should be accomplished with the least amount of pain and an uncomplicated healing experience.

At the first appointment, a full mouth radiograph is taken and a prophylaxis is administered. Articulated study casts should be made of the mouth as presented, and a careful survey of the entire case is made. This survey may include:

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(1) An appraisal of the lip position which may be affected by the thickness of the labial flange of the immediate denture. (2) The amount of positional correction which would have to be made of the anterior teeth both on a horizontal and vertical level. (3) The amount of restored vertical opening which the case might permit. (4) Any deviation from normal anatomy that may exist, such as a large torus, large interfering tuberosities, sharp spicules of bone, etc. (5) A roentgenographic observation is made as to the amount of alveolar resorption and the presence of any retained roots and areas of infection.

The presentation of this service to the patient should include an explanation in detail of its limitations and what can reasonably be expected. Color slides and a patient record movie are excellent aids in this discussion.

A fee for the work and a method of payment should be presented. The fee in the majority of cases should include a remake to be performed at the termination of the healing period which may be anywhere from three months to one year. In order to make this service complete, the importance of a discussion of the remake at the time the dentures are originally presented cannot be stressed too highly. The writer also feels that some type of budget system as a means of payment would make it possible for more patients to have this type of service, and also inspire their confidence in it.

Records should be made of each of the anterior teeth, being careful to record the size, shape, and location of the fillings and the individual markings. The vertical dimension is recorded in relation to the rest position and occlusal contact. An excellent observation to be made at this time is to appraise the amount of incisal clearance which can be achieved without infringing on the rest relation.

Basically we might consider that there are two types of immediate dentures: (1) the continuous flange type, and (2) the socketed type or open-front denture.

The continuous flange type is the generally accepted type of denture which is characterized by having a closed labial flange and which may be used where the lip position is not materially affected by the bulk of the labial flange of the denture. It may also be used where the labial plate is not prominent, and where little surgery is necessary to permit the insertion of the case.

The socketed type or open-front denture is one with an interrupted labial flange which permits the anterior teeth of the denture to extend into the sockets of the newly extracted teeth. This type may be used in thin or short lip cases, and in mouths where a prominent labial plate is present which requires extensive surgery in order to place the denture.

IMPRESSION TECHNIQUE

Trial impressions of both dental arches are made in alginate, from which soluble or investing plaster casts are made to include only the remaining teeth. These casts are carefully removed, and the complete impressions are poured in stone. These stone casts are then set aside until the final impressions are made. The duplication process of the anterior teeth may now be carried out.

DUPLICATION PROCESS

The soluble plaster casts of the anterior teeth are allowed to dry thoroughly. The separation of each tooth is accomplished by cutting through the cast with a circular saw on a mandrel. The cuts are made from the base of the cast into the embrasure between each tooth, after which the tooth is separated from its neighbor with a sharp instrument (Fig. 1). The contact area is allowed to remain intact, that is, it is not ground. The embrasure area is cleared of any excess material, and the base is tapered from the cervical margin of the tooth. The cervical margin is not ground, in order to preserve the original length of the crown.

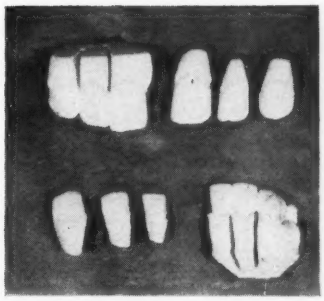

Fig. 1.—Casts of soluble plaster made in an alginate impression. The teeth are separated and the root ends tapered.

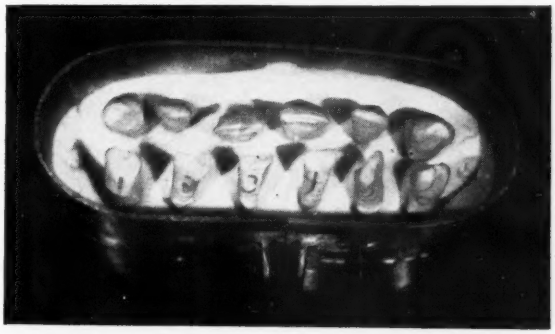

Fig. 2.—The oval metal ring with the tapered root ends of the casts of the teeth imbedded in plaster.

If the operator wishes to restrict the use of these teeth to a particular patient, a permanent record of these teeth is not essential. However, if we recognize the importance in the continued use of duplicated anteriors for all of our denture patients, a permanent rubber mold must be made. Following the suggestion of Bodine, a Permaflex cold molding compound may be used for this purpose. This is an excellent material, but the writer has found that Korogel may be used to better advantage, as the over-all dimension can be maintained without shrinkage. The material is far more elastic and as a result it will not tear.

TECHNIQUE FOR KOROGEL MOLD

An oval metal ring, large enough to include the twelve anterior teeth is placed on a glass slab, and half filled with plaster (Fig. 2). The prepared plaster teeth are inserted into the soft plaster in an upright position just deep enough to maintain their position, keeping part of the base and crown exposed. This entire assembly is placed in a drying oven after the plaster base has set, in order to dry this plaster thoroughly. Meanwhile, the Korogel material is heated to a pouring consistency by means of an infrared light. The dried plaster teeth are removed from

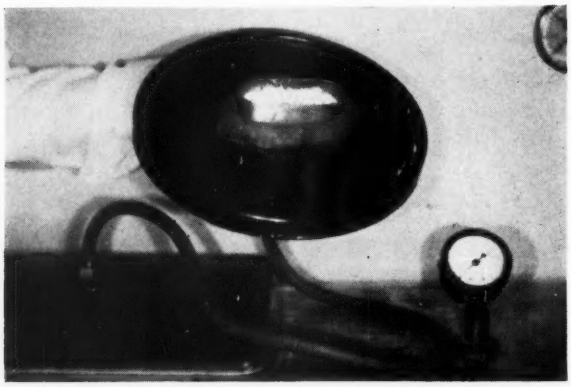

Fig. 3.—The vacuum apparatus attached to prevent air bubbles from forming in the Korogel.

Fig. 4.—A Korogel mold and a set of duplicated teeth.

the drying oven, and a separating material is painted on them. The metal ring is then attached to a base with a type of clay known as Raywalt compound in order to prevent air escaping from around the mold (Fig. 3.) This is then attached to a vacuum apparatus, and while vacuum is created, the prepared Korogel is poured around the plaster teeth in the ring. Korogel will bubble on cooling, and this vacuum will prevent the bubbling, and a solid rubber mold will result. The Korogel mold is allowed to cool and is separated from the plaster teeth and base. This mold and the stone casts of the original teeth are set aside and indexed for future use (Fig. 4).

The original plaster teeth, or the plaster teeth poured from the Korogel mold just made are painted or immersed in a separating medium. The excess separating medium is removed, and the teeth are invested in a flask where they are placed side by side in any convenient arrangement. Many investing materials have been suggested for tooth fabrication, but to date the writer has found nothing to take the place of a hard stone such as Duroc. Metal molds of the type used commercially are not practical inasmuch as the dentist must work with too great a number of molds. The flask used is made from two and one-half inch stainless steel pipe cut into pieces three-quarter inch in length. These pieces are dowled to fit each other

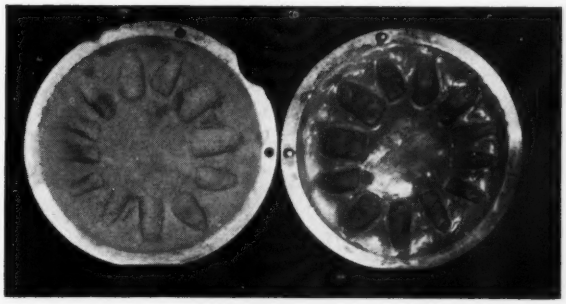

Fig. 5.—Stone molds of teeth in a flask.

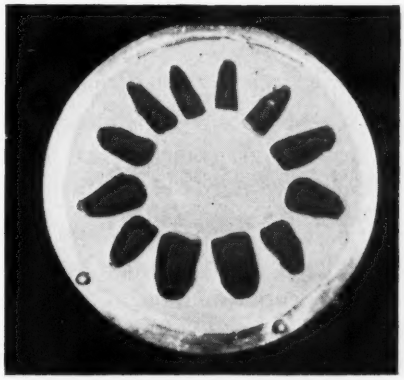

Fig. 6.—Plaster teeth in the bottom half of the flask with their labial surfaces exposed.

accurately (Fig. 5). The stone molds used in this work will be better preserved for repeated use if the plastic is molded within the confines of the flask but not processed in it. The mold is not exposed to heat. The plastic is allowed to remain in the stone mold under constant pressure for twenty-four hours, at which time the teeth are removed. This method will reduce the danger of breakdown of the stone mold, and it may be used to make several sets of teeth.

The plaster teeth are placed in the lower half of the flask with the labial surfaces exposed (Fig. 6). When the stone has completely set, the second half of the

flask is poured. When this stone is set, the flask is opened and the plaster teeth are carefully removed, leaving a mold which is painted with a tinfoil substitute. This is allowed to dry thoroughly.

PACKING THE PLASTIC TEETH

Dry Method.—The dentine powder is placed in the mold along with the incisal powder. It is then wetted with monomer, and more powder is added until sufficient body is built up to insure an excess of the material.

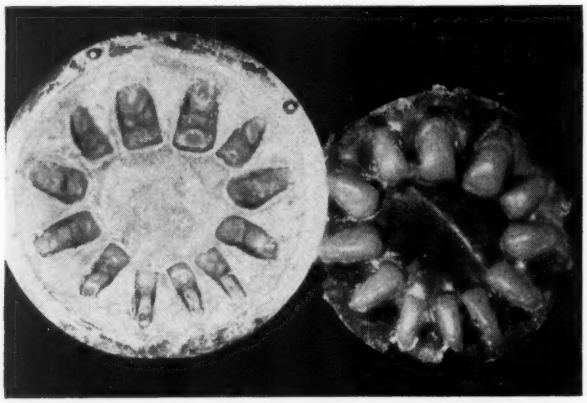

Fig. 7.—Semi-cured plastic teeth removed from the flask.

Wet Method.—The dentine and incisal powders are placed in separate jars and wetted with monomer. The dentine color is placed in the various molds in excess of the amount needed, leaving just enough space for the incisal color which is placed so it extends over about two-thirds of the dentine material.

It is very important, in either method, to reshape the mass of material in each mold to rearrange the molecules of plastic at this time in order to avoid a sharp line of demarcation between the dentine and incisal colors. The plastic is allowed to set to a rubbery consistency, and the two halves of the flask are closed with considerable pressure. The flask is reopened, the teeth removed, the flash is cut off and the teeth are returned to their respective positions in the mold. The halves of the flask are closed again to seat the teeth firmly in the molds. Once again the flask is opened, and the teeth are characterized. The teeth are solid at this stage but soft enough so that enamel cracks, fillings, etc. can be inserted with a very simple technique. A sharp knife will cut the plastic to the depth required, and the dry colored powder can be inserted in the cuts. The excess colored powder is brushed off. This will produce a sharp thin line for an enamel crack or a filling. Gold fillings can also be inserted at this time. They can be placed into the soft plastic under pressure. The flask is again closed with pressure, and the teeth are allowed to remain in the flask under pressure for twenty-four to forty-eight hours, at which time they may be removed (Fig. 7). The con-

sistency of the plastic is just hard enough to resist distortion at this time. The ultimate processing is done at the time the dentures are completed. The reason this method is suggested is to better preserve the stone mold. If the teeth are not processed at this time, they are more easily removed, and the stone mold may be used again. The flash around the teeth is trimmed away, and the teeth are mounted on a piece of counter wax until they are used (Fig. 8).

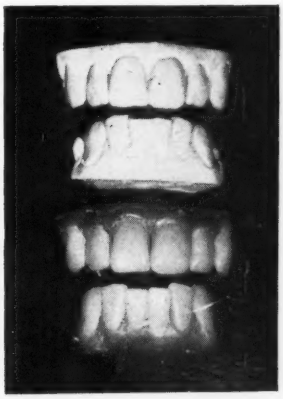

Fig. 8.—The plastic teeth mounted on counter wax. They are accurate duplicates of the stone teeth.

MAXILLARY IMPRESSION

The final impressions are taken at the next appointment.

A shim or spacer of either baseplate or wet asbestos is placed over the remaining teeth on the original cast. Processed or double thickness base plate material is adapted over this cast and shim. This allows the baseplate to slide on and off the cast easily. A final alginate impression is made in this prepared tray. Care is used to prevent the tray from showing through the impression material.

MANDIBULAR IMPRESSION

A slight change in technique is suggested for the impression of the lower jaw. A single thickness baseplate is adapted over the edentulous part of the arch. This is reinforced with one of the activated acrylics. A spacer is placed over the anterior teeth, and a loose fitting double thickness baseplate is adapted over both the spacer and the original baseplate. A corrective paste impression is then made in the original baseplate. Finally, an alginate impression which includes the corrective paste impression and the remaining teeth is made in the double thickness baseplate of the entire assembly.

Upon the removal from the mouth, these impressions are carefully washed to remove any saliva and debris, and the previously prepared plastic teeth are carefully inserted into their respective positions in the impressions. Artifical stone casts are then poured into the impressions. Care must be taken to be sure that the plastic teeth are firmly seated in the impression. The anterior teeth on the casts will

be of plastic rather than of stone (Figs. 9, 10, 11, and 12). The setup of the six anterior teeth can be accomplished with more precision than could be done by sawing the anterior teeth from the cast, and replacing them with denture teeth. A baseplate of an activated acrylic resin is made to fit the edentulous areas with care to avoid extension into undercut areas. These baseplates are fitted with wax occlusion rims to record the jaw relations. A face-bow is attached to the upper occlusion rim, and the upper cast, which is carefully keyed for remounting, is attached to the articulator.

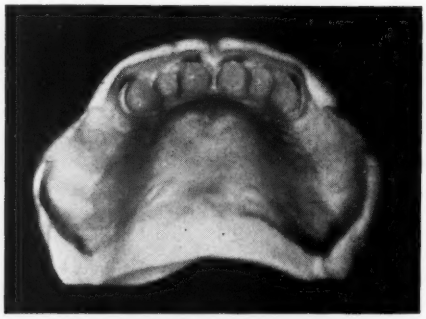

Fig. 9.—The plastic teeth seated in the final impression.

Fig. 10.—The cast of the jaw with the plastic teeth in exactly the same position as the teeth they are to replace.

JAW RELATION RECORDS

After returning both baseplates to the mouth, the patient is allowed to close into soft wax for a preliminary centric relation record. The lower cast is mounted on the articulator by means of this wax checkbite. This initial mounting of the casts permits the operator to correct the occlusal plane prior to the mounting of the intraoral tracers.

Using the rest position as a guide, the amount of free-way space is noted. The accepted phonetic tests may be used, including Mississippi, sixty-six, this and that, and finally A-M-S. These tests may show that while space exists in the posterior part of the mouth, no incisal clearance is evident at the rest position. Opening the vertical dimension to clear this incisal relationship can lead to disaster in many cases. Shortening the anterior teeth or deeper socketing can be the only

answer in these cases. Often a change in the position of the anterior teeth in their relations to each other is a compromise in order to preserve the cosmetic effect.

After the vertical dimension has been established, a centric recording instrument is mounted on the wax occlusion rims. This must be some type of intraoral tracer. With the central bearing pin in proper position, plaster is injected between the occlusion rims by means of a plaster gun to record the jaw relation. If it is possible to obtain incisal clearance, eccentric jaw movements are made and a Gothic arch tracing is obtained to verify the recorded centric relation. At this

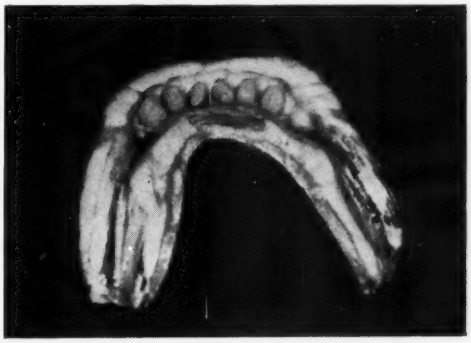

Fig. 11.—The lower final impression with the plastic teeth in position ready for cast pouring.

Fig. 12.—The lower cast with the plastic teeth in position to duplicate the position of the natural teeth.

stage in many cases, the incisor tooth relationship is open on the articulator in comparison to the relationship in the mouth. This may be due to tissue displacement under the baseplates when pressures are applied as the jaw relation record is made. Care must be exerted, in making this jaw relation record, to have the pin touching the table lightly so the injected plaster can preserve this relation. The relation of the casts on the articulator is corrected by remounting the lower cast according to the plaster checkbite.

The posterior teeth are then set up, recognizing that settling of an immediate denture is the usual rather than the exceptional. Posterior teeth should be used that will permit this change with the least irritation to the ridges. Flat cusp teeth are the posterior teeth of choice. New posterior teeth may be substituted at the end of the healing period when the dentures are duplicated.

The baseplates with the trial setup are tried into the mouth. The patient is directed to make the various mandibular excursions to check the amount of incisal clearance, or to determine the amount of incisal clearance that can be effected at the accepted level of vertical opening. If the jaw relation check is acceptable, a plaster record of the face-bow relation on the articulator is made for future reference.

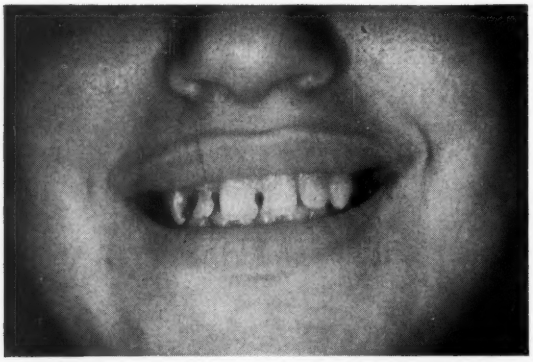

Fig. 13.—Woman aged 18 years at first visit. Carious teeth must be restored in wax prior to duplication.

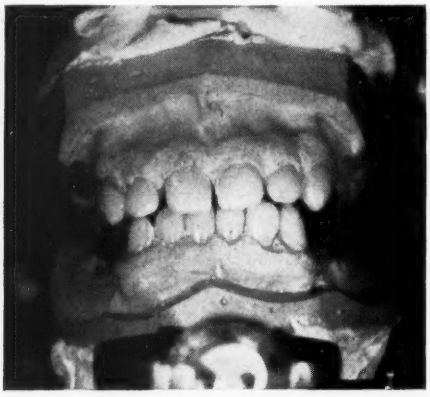

Fig. 14.—Duplicated anterior teeth in place on articulated casts.

LABORATORY PROCEDURES

The plastic anterior teeth are loosened from the stone cast, and additional retention cuts are made in the stumps of these teeth prior to the wax up. They are then waxed to place, and the wax up of the denture is completed. The labial flange is left unwaxed to permit the socketing of the anterior teeth. The wax up must be heavier at the lingual cervical margin of the anterior teeth to provide additional strength, and to prevent separation of these teeth from the base during the treatment period. The dentures are invested in the flasks with a slight anterior tilt to allow for easier separation of the flasks prior to the packing of the

acrylic material. The dentures are processed and remounted on the articulator by the split cast method for selective grinding and milling, before the final polishing and finishing.

SURGERY

The usual denture that is socketed will permit the insertion of the denture with the simple extraction of the anterior teeth and nothing more. Surgical preparation of the ridges at the time of the insertion of the denture is the rare exception rather than a routine procedure. This statement applies, however, when the

Fig. 15.—Finished dentures with anterior teeth ready for socketing.

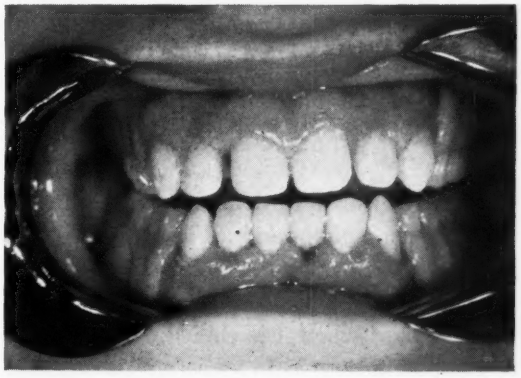

Fig. 16.—The dentures two weeks after insertion.

socketing principle is used with duplicated anterior teeth. A local anesthetic is used in conjunction with analgesia. The patient should be premedicated and the shock of tranferring from natural dentition to a denture is reduced to a minimum. The upper immediate denture is inserted first, and the lower is inserted a week later. This prepares the patient for the more difficult experience with the lower denture (Figs. 13, 14, 15, 16, and 17).

The patient is given instruction in the use and handling of the dentures. Post operative adjustments are discussed and a suggestion is made for the patient's return.

REMAKE

Thought must be given to remaking these immediate dentures. It can be accomplished by: (1) Completely remaking the upper and lower dentures. This may not be practical as the additional cost may limit this type of service. (2) A reline or rebase. This has not proved practical as the occlusion cannot be corrected sufficiently to perfect completely many of the dentures. (3) Duplication. This is a most practical method to carry the patient from the treatment dentures to the final dentures. This permits the establishment of new intermaxillary relations and the opportunity to substitute new posterior teeth on the dentures.

Fig. 17.—Finished dentures.

DUPLICATION

A duplication of these dentures is done in this manner. The labial flange is first restored in modeling compound, and an impression is made in each denture with a corrective paste. The dentures are then tested for retention and stability. The teeth are cleared of any excess impression material, and a checkbite is made in a wax that becomes very hard when it is chilled. This checkbite is removed and laid aside. The impressions are poured in stone, and a stone index is made of the teeth. The casts and dentures are mounted in a duplicating type of articulator. The teeth are removed from the denture base and reset to the new cast with the aid of the index. Using the original plaster record, the upper cast and denture are reattached to the original articulator. The lower cast and denture are attached to the articulator by means of the wax checkbite. The teeth are now reset to the adjusted cast relations on the articulator, and cusp posterior teeth are substituted at this time. The dentures are processed and remounted on the articulator, and the occlusion is adjusted before delivery to the patient.

SUMMARY

A most important step in immediate denture construction is an accurate duplication of the anterior teeth and their position. The inaccuracies of reproduction with the use of stock teeth must be recognized. Many mouths require the use of the socketing principle to facilitate the insertion of an immediate denture. This combination of socketing and tooth duplication results in a denture service free from many of the complications which have confronted us in the past.

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PROGRESS REPORT ON IMMEDIATE PERMANENT RELINES

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THIS report is only a progress report on immediate permanent relines since it will take years to arrive at final conclusions.

The original reports by Skinner and Pomés[1] and Beall and Caul[2] indicate that the first immediate liners were satisfactory at the onset, but within a few months they displayed a great tendency to further warp the denture and disintegrate the original base. The ethyl and amyl acetate and the diethyl carbonate and the triacetin contained in these reline materials all proved to be unsatisfactory media for this work.

The swing then was back to the old methods of rebasing or relining. Among the methods recommended are Christie's[3] processing for six hours at 165°F., or at 135°F. if the inhibitor had been distilled away. Hardy[4] recommended removal of the palatal area of the old denture, and Tuma[5] recommended the heating of the flask to 550°F., in an inlay furnace to sufficiently destroy the old base that it might readily be removed from the flask. (This method could be used only with porcelain teeth, of course.)

Since it is a well known fact that the thermoplastic bases used for dentures are subject to change on reheating, we still sought to use the auto-polymerizing resins for relining, and the manufacturers gradually came forth with materials with essential compositions of methyl methacrylate. Bureau of Standards researchers as well as others[6] have indicated that the autopolymers have greater accuracy of fit than heat-cured acrylic (Fig. 1). Much effort has gone into the process of improving the tensile strength and hardness of the materials.

One of the causes of failure in the use of the autopolymers in both relines and repairs lies in the improper handling of the material. It hardens before it reaches a doughy mass and before the repair or reline can be completed.[7] Thus, in place of making a new solid unit, the result is that of using two separate parts of a denture in the effort to create one. Even in the first methacrylate liners, so much of the catalyst and solvents were incorporated in the polymer that it continually worked upon the base, especially when a flasking procedure was used.

A good deal of work has been done on testing the newer reline materials, but more awaits before any real conclusions can be drawn. Clear bases that have been relined with the best available products have been both chilled and boiled, kept in and out of the environment of the mouth for over six months, and at this writing

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show no signs of change. There is an indication that different base materials are affeced in different manners by the relines. The pure methyl methacrylates show a tendency to craze, copolymers show a slight degree of crazing, and the cross-link materials apparently show no change when used with immediate reliners under mouth pressure and mouth temperatures.

The best technique our group has found for practical use is to cleanse thoroughly the partial or full denture to be relined, first with soap and water and then with pumice at the lathe. The cleansed, and now slightly roughened tissue surface is again washed with soap and water and dried with an air blast. The surface to which the reline is to be attached is wetted with the monomer of the reline material to a line approximately 1/16 inch over the flanges and periphery. This will make for a better attachment and create a fine finish line.

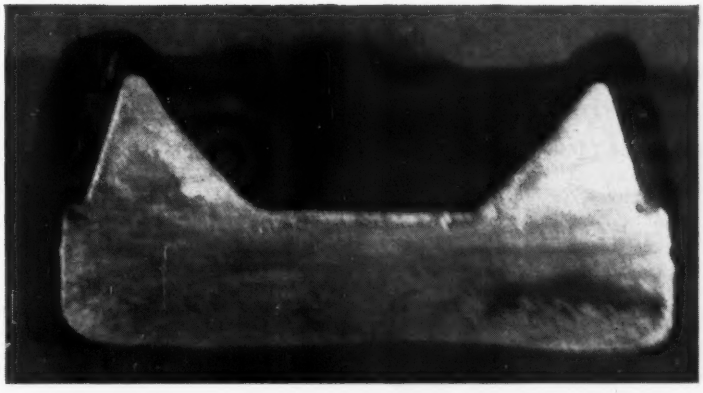

Fig. 1.—An autopolymerized base on a Bureau of Standards Die.

The material is mixed according to the manufacturer's directions and applied to the base in a sufficiently limited quantity to insure a fine roll without adding bulk to the denture. (Again, as in all plastic materials use, it is important to remember that the powders and liquids of various manufacturers' brands are not interchangeable, and each powder should be used only with its own brand of liquid.) Whenever possible the liquids should be kept chilled during storage, and the bottles shaken vigorously before portions are measured.

The material should remain on the base outside the mouth until the glaze starts to disappear, at which time it is rinsed in tepid water and inserted in the mouth. If the patient is extremely sensitive to temperature changes or irritations, a slight coating of glycerine over the material will protect him and leave a sweet taste in the mouth. The denture is carried to the mouth and guided by gentle pressure and the patient's closure into centric occlusion. It is then muscle-trimmed by the patient's own movements of the tongue and cheek, and allowed to remain until the patient reports a feeling of discomfort. The denture is removed and rinsed in cool tap water, and returned to the mouth. The occlusion is rechecked since the material is still pliable enough so the denture may be guided into proper placement.

It may or may not be necessary to make additional removals before the chemical curing cycle is completed. The elapsed polymerization time can be determined by having the patient hold a small quantity of the excess material in the closed fist until it hardens. The mouth curing cycle will be found to be the same, and the denture may be removed, adjusted and polished, and returned immediately to the patient.

Of the many dentures treated in this manner, in not one denture has there been a separation of the material from the denture base, nor have there been any signs of tissue irritation from these relines. The characteristic odor of the autopolymer appears to be that of the oxidation process within the material. When ground on a lathe, the odor from a denture that has never been inserted in the mouth will be identical to that of one worn for either a short or long period of time. It is not possible to discern this characteristic odor in the mouth of a patient using a denture with this type of reline.

It is to be desired that we may soon have accurate and permanent data on both the expectations and proper handling of these dental materials.

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GOLD INLAYS CAST INTO PORCELAIN TEETH

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ESTHETICS sometimes require the placing of gold inlays in the teeth of artificial dentures. This can best be done by casting the gold directly into properly prepared cavities in porcelain denture teeth. If a few simple rules are followed, any dentist or technician can obtain excellent results with the expenditure of little time or money. A stock of twenty-five or fifty teeth can be made up in the most popular molds and shades (Fig. 1). The teeth replaced can then be used to replenish the original stock.

The gold used for casting should be of high quality, extra hard partial denture gold. Cheap gold is likely to tarnish, while the best gold will retain a fine finish with perfect margins.

An excellent esthetic effect can be obtained by placing inlays on the mesial of bicuspids and molars. These do not always show, but can be seen from the side and when the patient smiles. Of course, some patients like to have more gold showing, so for these patients class three inlays can be used in the anterior teeth.

Thin castings are better than thick castings for these inlays. They should be 0.25 to 0.50 mm. in thickness. This will conserve gold and reduce the shrinkage.

The preparations in porcelain teeth are made very shallow. The cavity outline is made with a small stone. The main retention for the inlay in anterior teeth is obtained by waxing the pattern to the base of one pin (Fig. 2). The other mechanical lock is made in the labial surface of the preparation by cutting a small groove with a knife-edged diamond stone or a one-quarter inch Joe Dandy disk. It may be made by using a shingle nail that has been sharpened to a knife edge with a file while it is turning in the lathe. The reshaped shingle nail is used with an abrasive paste (Carborundum). When used in this manner, it cuts porcelain quickly. Care must be used not to cut the fingers.

The preparations in biscuspids and molars are made by grinding the mesial and buccal surfaces to the shape of the inlay desired with small stones (Fig. 3). The mesial retention hole in the tooth is waxed over for retention, and a vertical groove is cut on the buccal surface of the preparation to act as a lock.

Open-faced crowns can be made by grinding the entire circumference of an anterior tooth lightly with a stone (Fig. 4). The wax pattern must be formed completely around the tooth. The margins are carried slightly onto the labial and lingual surfaces. The wax pattern is carved to a uniform thickness.

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Three-quarter crowns can be imitated by first casting an open-faced crown but with the pattern waxed to the pins. Then the gold at the cervical is cut off.

Inlay wax is melted onto the tooth to make the patterns. The wax sticks to the ground surfaces of the porcelain, and is easily removed from the glazed surfaces. Fine margins can be made on the patterns by wiping the wax toward the margins of the preparation with a piece of silk or linen. This reduces the finishing time required.

Fig. 1.—A selection of porcelain teeth with various types of imitation restorations.

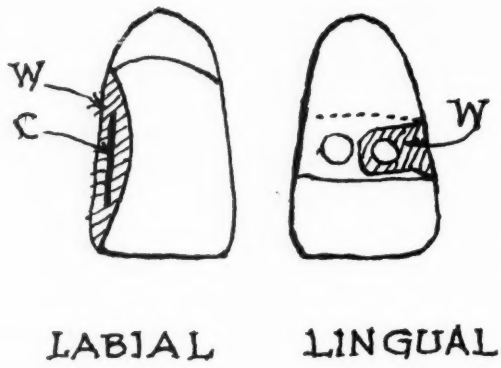

Fig. 2.—The preparation and wax pattern for an inlay in an anterior artificial tooth.
W—The outline form of the preparation.
C—The retention groove.

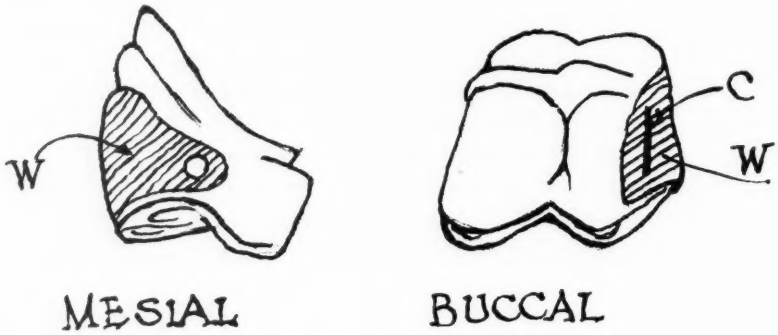

Fig. 3.—The preparation and wax pattern for an inlay on a molar tooth.
W—The outline form and wax pattern.
C—The retention groove.

Sprues are cut from paper clips. Six to ten inlays are cast at one time in an ordinary inlay ring. Larger rings make it possible for twenty to thirty inlays to be cast at a time (Fig. 5).

Successful casting depends upon a high burnout temperature and slow cooling. This will prevent checking of the porcelain teeth. The following sequence is of essential importance. The gold is melted in the casting crucible first. Then the inlay ring is taken from the furnace at 1400 degrees F., and the casting is made

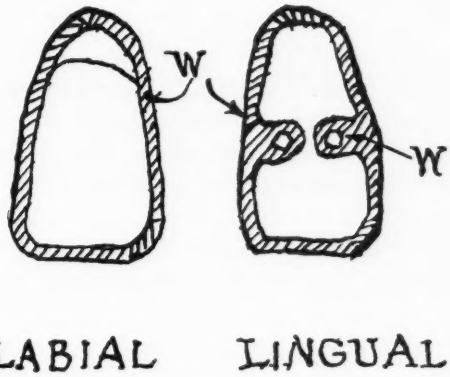

Fig. 4.—The preparation and wax pattern for an imitation open-faced crown.
W—The wax pattern.

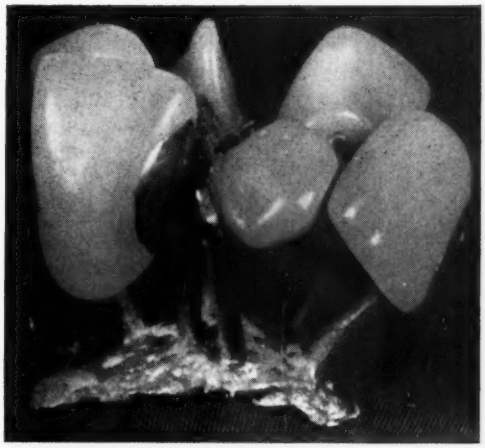

Fig. 5.—A cluster of inlays on porcelain teeth cast at one time.

immediately. As soon as the casting machine stops rotating, the ring is replaced in the burnout furnace, and the furnace is turned off. The furnace is allowed to cool overnight, or until the casting ring can be handled in the fingers. Do not quench in water.

If the waxing was carefully done, little polishing will be required.

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THE TEMPOROMANDIBULAR-MAXILLARY RELATIONSHIP

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TEMPOROMANDIBULAR-MAXILLARY relationship infers that the relationship the mandible bears to the entire skull is a single, balanced position. Many theories have been advanced, and much investigating has been done in regard to the centering of the mandible and occlusion by means of the Gothic arch tracings.

It is apparent from the study of geometry that equilateral and isosceles triangles may be bisected by arcs scribed from points at the extremities of their bases in a single plane. The tracing of the Gothic arch made by lateral excursions of the mandible will indicate a horizontal center, provided that the pivot of each arc is fixed at one point. The apex of the Gothic arch is full of vagaries. This is evidenced by the numerous techniques which have been devised to center the center, and other means of trial and error.

To many prosthodontists, the Gothic arch represents the ideal, and their efforts and teachings have been directed toward this goal.

There are many motions in the temporomandibular articulation, e.g., lateral, lateral excursions, protrusion, rotary, up and down, and gliding. In a well-made denture, all of these motions must be accommodated. One group of motions that is of the most importance is the masticatory cycle. This cycle requires the use of all muscles of mastication, and involves all primary positions and movements of the condyles and teeth, from the reception of the bolus of food to the final swallow.

The problem of the accommodation of this cycle is to place the mandible at a position of final closure. This is a position of static equilibrium; static equilibrium being that position at which vertical height is correct, the condyles are balanced in their fossae, and the muscles of mastication are in functional balance.

I have been able to study the closing phase of the masticatory cycle by means of an instrument I developed.

THE MUSCLES OF MASTICATION

To note what happens in the closing phase of the masticatory cycle, one must be able to visualize the origin and insertion of the muscles of mastication, their direction of force in contraction, the value of their effort in pounds of force exerted, and have an understanding of the movements of the meniscuses as their position is constantly being shifted by the external pterygoid muscles on the surfaces of the

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condyles and the glenoid fossae. An excellent understanding of the direction of force applied to the mandible is gained by studying the vectors of the muscles of mastication. These are the temporal, masseter, external pterygoid, and internal pterygoid muscles (Fig. 1).

It will be noted on the line drawing that the resultant force at the completion of this polygon will be in an upward and forward direction. This indicates that the force applied by the condyles to the fossae is against the articular tubercles. This is contrary to the theory that the condyles rest against the posterior walls of the glenoid fossae.

THE TEMPOROMANDIBULAR ARTICULATION

A study of the anatomy of the temporomandibular articulation reveals that it is composed of three articulating structures.

1. The glenoid fossa, described as an oval depression on the underside of the temporal bone, has its long axis pointed inward, backward and downward in the direction of the foramen magnum, and is covered by articular cartilage. This results in a diverse axis at approximately a right angle to the line of force of the external pterygoid muscle.
2. The meniscus is described as an articular disc, convex above, conforming to the glenoid fossa, and concave below, conforming to the condyle. Its posterior border is thicker than its anterior, and it is separated from the fossa and the condyle by synovial cavities.
3. The condyles are convex anteriorly, and are slightly flattened on the superior surface. The long axes are not transverse, but do generally follow the axes of the glenoid fossae. The condyles are covered by articular cartilage on the anterior and superior surface, and have eccentric articulating surfaces; discrediting the theory that the "rotation of the mandible is on a true axis."

The rotation of the mandible from its rest position towards the position of occlusion is created by the temporal muscle. This muscle is inserted into the coronoid process of the mandible at a cant position. This results in the condyles being pulled backward and downward as the eccentric surfaces of the condyles rotate on the meniscuses, and the anterior position of the mandible being tipped upward towards occlusion. It is well to note that the external pterygoid muscle is inserted into both the neck of the condyle and the inner side of the meniscus. The function of each insertion is different; the insertion into the neck of the condyle pulls the condyle forward and toward the midline of the skull. The insertion into the meniscus pulls the meniscus forward and rotates it about the head of the condyle, creating a wedging effect between the condyle and the articular tubercle.

VERTICAL DIMENSION

Vertical dimension is of the utmost importance, and should always be a measurement of vertical height at occlusion. It may be determined in various ways,

such as measurements before extraction, profile gauge measurements, phonetics, and by other means.

I suggest "time" as an element of measure for determining vertical dimension. This method is based upon the facts that muscles rest at their normal length, and that there is a measurable length of time that a cycle of muscular contraction and extension requires. The procedure is used to adjust occlusion rims to determine the normal vertical height for the patient. This is accomplished by having the patient bring the occlusion rims into contact, and noting the length of time the rims remain in contact before the mouth opens involuntarily. Normal separation from contact takes place from three to four seconds.

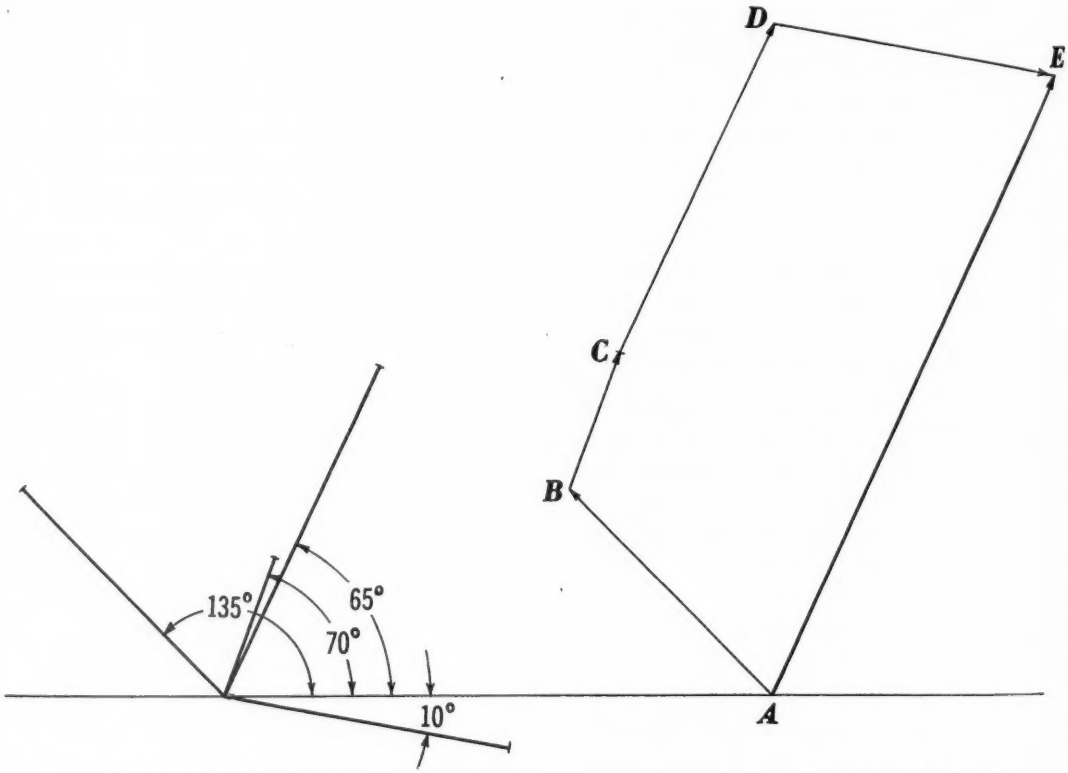

Fig. 1.—*A*, The vectors of the muscles of mastication. Left to right: temporal, internal pterygoid, masseter, external pterygoid. *B*, A polygon of the vectors showing the resultant direction of force to be in an upward and forward direction.

If the vertical height is too great, the occlusion rims will stay in contact more than six seconds. They will separate only when fatigue causes the muscles to relax to a rest position without completing the cycle of contraction and extension. If vertical height is too low, the occlusion rims will separate in less than three seconds, or contact will be made by effort.

This technique relieves the patient of the embarrassment of faulty pronunciation, when called upon to repeat letters, words or sentences while the occlusion

rims are in the mouth. It also permits the dentist to secure the vertical dimension measurement without the help of the patient, since the opening and closing of the mouth is involuntary.

FREE-WAY SPACE

The free-way space is defined as space between the upper and lower teeth while the muscles controlling the mandible are at rest. It is more logical to assume that the free-way space represents the distance in which the muscles contract in their cycle for any one individual rather than a definite distance for all patients. For example: if a patient is provided with a three millimeter free-way space when the length of contraction is six millimeters, the patient will eventually collapse the ridges to secure the needed space with accompanying protrusion and shortening of the vertical dimension.

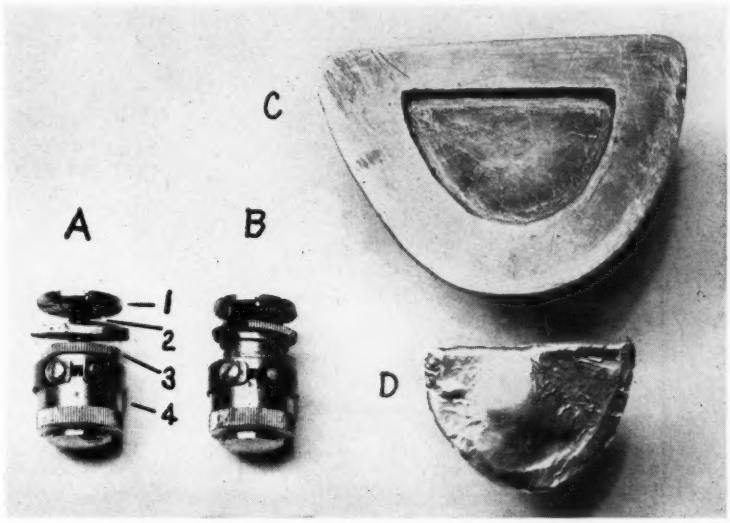

Fig. 2.—The instrument. *A*, The upper part: *1*, attaching plate, *2*, adjusting screw, *3*, lock-nut, *4*, capsule latched. *B*, An unlatched capsule. *C*, The lower part, or plate with the center depressed. *D*, Wax and tin-foil wafer for insertion into the depressed area of the lower part.

THE INSTRUMENT

The instrument which I have perfected consists of two parts (Fig. 2). The upper part is composed of an attaching plate, adjustment screw, lock-nut, and a capsule. The capsule consists of inner and outer cups, containing a volute spring which is capable of resisting approximately ten pounds of closing pressure. The cups automatically latch upon compression and are released to extension by rotation of the outer cup. The outer cup is provided with a semi-spherical stylus.

The lower part of the instrument is a flat plate with the center area depressed for the purpose of receiving a wax wafer covered by 0.004 inch of tin foil. The wafer will become invaginated by the stylus as the upper part of the instrument is compressed against the lower part.

TECHNIQUE

Once the vertical height has been secured by means of the occlusion rims, the rims are placed in the mouth and are held in the occluded position until they have been stapled together, after which they are removed as a unit. The prepared casts are inserted into the occlusion rims and are temporarily mounted on an articulator. This is done for the purpose of retaining their relationship while the instrument is being attached to the upper and lower bases. The upper part of the instrument is attached to the palatal area of the upper baseplate by means of modeling compound. It is centered laterally, in a vertical position, on a transverse line between the first bicuspid teeth. During this procedure the capsule must be in a latched position (Fig. 3).

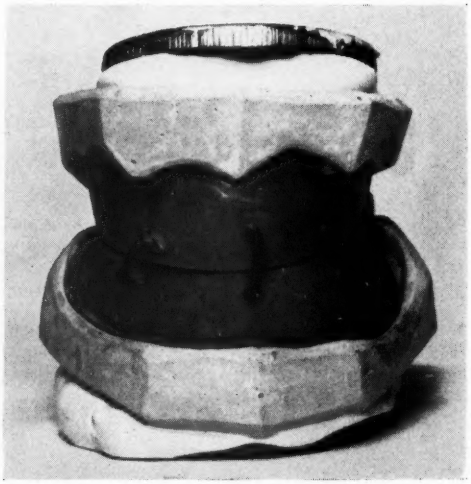

Fig. 3.—The vertical height has been established by the occlusion rims and the casts are mounted temporarily in order to attach the instrument.

To attach the lower part, the plate is first heated and then seated in the wax of the lower occlusion rim in a horizontal position to a depth determined by the stop screw of the articulator. Wax is trimmed from the occlusion rim level with the surface of the plate. This usually leaves sufficient space between the occlusion rims to permit the mandible to assume a position which will produce a balanced relationship between the fossae and the condyles. The baseplates should be tried in the mouth to ascertain if there is any contact other than between the two parts of the instrument. If so, the contact points should be cleared (Figs. 4 and 5).

The baseplates are removed from the mouth, and the capsule is released from the latched position by rotating the outer cup. The cup should be further rotated to a position where the cup will again latch when the capsule is compressed. A beeswax and tin-foil wafer is then placed in the depression in the lower plate.

The occlusion rims, with the instrument in place, are inserted in the patient's mouth. The mouth is opened as wide as possible to move the condyles from the

fossae, then it is closed slowly. A slight thud will be noticed as the condyles return to the fossae. The closure is continued slowly until the capsule is compressed and latched. At this point the occlusion rims are stapled together to maintain the relationship for re-articulation on a plane line articulator with an incisal support. This technique is one of static equilibrium so no motion is to be toler-

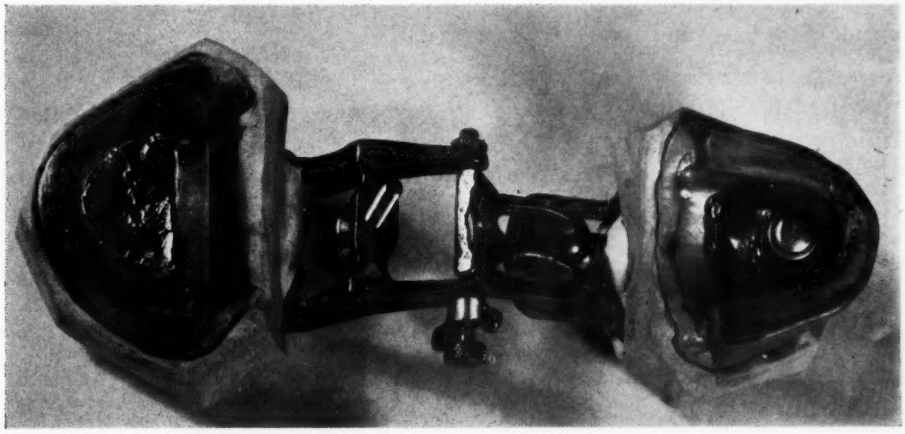

Fig. 4.—The instrument is mounted with the capsule in a latched position. The upper part of the instrument is in a vertical position, and centered laterally on a transverse line between the first bicuspid teeth. The lower part is seated in the lower occlusion rim to a depth determined by stop screw of articulator which was set at a determined vertical height.

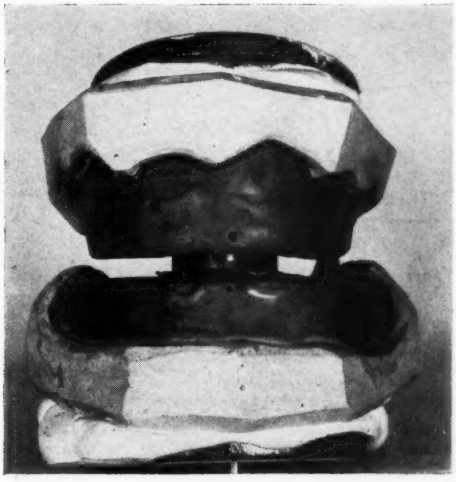

Fig. 5.—The articulator is closed with instrument in place. The clearance between the occlusion rims permits the mandible to assume a position of equilibrium.

ated in the articulator, except in the hinge which is used for convenience in setting up the teeth.

The instrument provides an unbalancing stimulation to the muscles of mastication at the apex of the temporomaxillary triangle. It does not have a central

bearing point. The base of the temporomaxillary triangle is the line between the two points at which the condyles balance in their fossae. The apex of the triangle is the point of contact of the stylus with the lower plate. The base of the temporomandibular triangle is the line between the two points of contact at which the condyles balance in their fossae. The apex of the triangle is the contact point of the lower plate against the stylus. The coincidence of these two triangles represents complete occlusion at equilibrium. (The included planes of two triangles will coincide if the bases and apices coincide.)

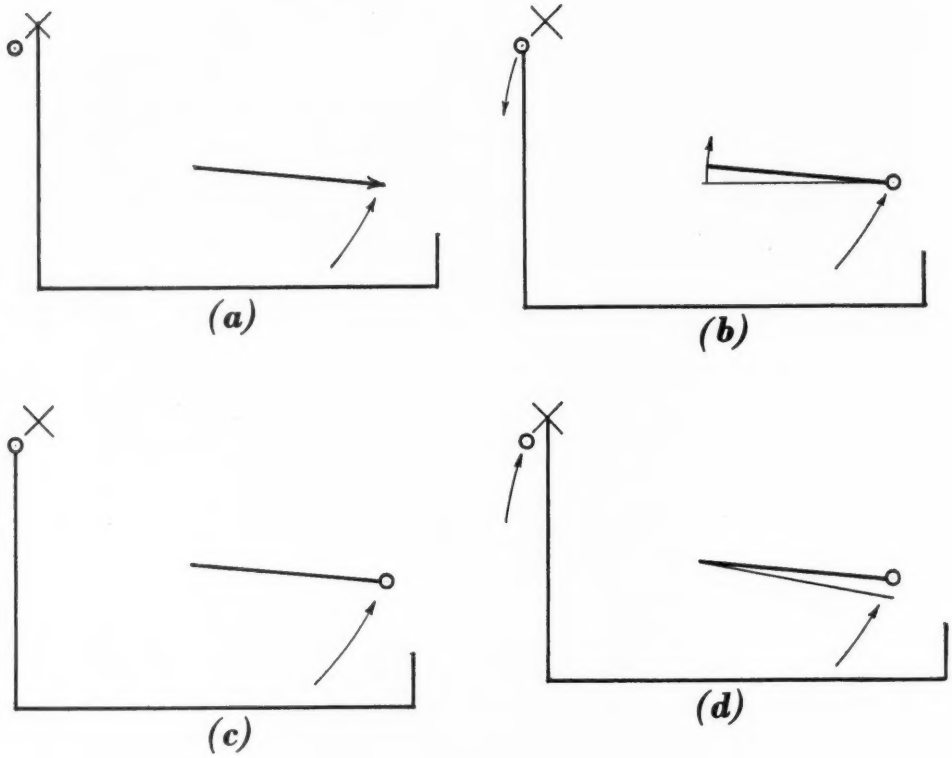

Fig. 6.—The closing movements of the mandible.

x represents the point of contact by the condyle at equilibrium.
⊙ represents the position of the condyle at centric relation.
— the heavy line represents the maxillary occlusion.
— the light line represents the mandibular occlusion.

A, Occlusion at equilibrium. *B*, Separation of the posterior teeth when the condyle drops to centric relation. *C*, Occlusion at centric relation. *D*, Separation of the anterior teeth when condyles are brought to contact when the teeth are set up at centric relation.

As relaxation of the muscles from a firm balance occurs, the teeth separate from the posterior to the anterior. This frees the cusps of the posterior teeth, and permits a normal physiologic balance and function between the component muscle groups. Under these conditions, the ridges remain firm and healthy over a long period of time because of minimum anterior and lateral thrusts.

Any change in vertical height requires a new record of equilibrium because these changes disturb the equilibrium.

Grinding of occlusion to lateral excursions reduces the vertical height of the dentures. It also destroys the clearance between the posterior teeth which represents the distance from the point of centric relation to equilibrium. This clearance is most important to denture patients.

OBSERVATIONS

I have used this instrument to observe the movements of the mandible while recording equilibrium. The symphysis of the mandible tips upward as it rotates from a rest position until an initial contact is made in the region of the first bicuspid teeth, and at this point rotation ceases in the glenoid fossae and a second motion then begins. The mandible rotates on a transverse axis between the mesial surfaces of the cusps of the upper first bicuspids and the distal surfaces of the lower first bicuspids as points of articulation. This raises the posterior portion of the mandible to close the temporomandibular joint tightly, and brings the posterior teeth into occlusion (Fig. 6).

The second motion is the most important, as it closes the mandible to equilibrium, and eliminates premature contact on the posterior teeth which can result in "clicking." This second motion prevents the posterior teeth from acting as a fulcrum, and permits the lower molars to approach the upper molars at right angles to the chord of the arc of the external oblique line on the mandible. Pressure on the mylohyoid ridge is eliminated, and a denture space and vertical height are established in the posterior region. The free-way space is wedge shaped as occlusion is approached, with the base of the space toward the posterior. During the rotation of the mandible in the fossae, the wedge-shape space has its base toward the anterior.

OCCLUSION

The study of occlusion developed by means of the use of this instrument shows it to be at equilibrium at the point from which no further closure can be made. With the vertical height established and the muscles balanced by stimulating pressure, the condyles are balanced in the fossae. The relaxation from these conditions permits the mandible to drop back to centric relation, a point from which all unhindered motion can be made. It is well to note that there are varying distances from centric relation of the mandible to equilibrium of the mandible. This distance varies from side to side, depending upon the various depths and sizes of the condyles and the fossae. This distance provides a clearance between the occluding surfaces of the teeth posterior to the first bicuspids. The freedom of occlusion developed avoids the necessity for grinding the teeth, except for an occasional spot grinding which may be required as a result of warpage in the base material. Premature contacts of the molar teeth are avoided, as they are usually the result of an inability to close the temporomandibular joints to their positions of equilibrium.

Anatomic, 20 degree, Geometric, Zero, French, and Nic posterior teeth have been used with satisfactory results. The teeth are set in normal occlusion, with re-

spect for the laws of levers. With this intermaxillary record, I have noticed very little wear when plastic teeth have been used.

The esthetic effect of the dentures has proved to be excellent, because the muscles of mastication and expression have a normal freedom of action. This restores to the patient a natural appearance.

SUMMARY

Equilibrium is the terminus of all closing motion of the mandible. It represents a centered balanced position of the mandible at a fixed vertical height.

The method of using time as an element of measure for determining the vertical height has been very successful, and is extremely sensitive to slight variations.

The secondary or reverse motion of the mandible, with its axis on the occlusal surfaces of the first bicuspid teeth, permits normal apposition of the teeth, closing of the temporomandibular articulation, and avoids lateral and anterior thrusts which would result from pivoting on the distal margins of the lower molar teeth. The closing of the joint avoids pressure, soreness of the mylohyoid ridge, and a "searching bite." This intermaxillary record as a whole produces a comfortable, efficient, pressure-free set of dentures.

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THE SPEAKING METHOD IN MEASURING VERTICAL DIMENSION

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THE exact measurement of the natural vertical dimension is most essential in the successful practice of many phases of dentistry. It has been found that the greatest cause of full denture difficulties is the failure to duplicate the normal vertical dimension. In occlusal reconstruction, many fine dentists have found, through experience, that increasing the vertical dimension for patients with supposedly shortened vertical dimension ended in failure.

The dental profession realizes that it has never had an accurate, scientific, and practical method with which to measure the patient's natural vertical dimension. It is now possible by the use of the speaking method to measure a patient's vertical dimension *before* the loss of the remaining natural teeth, and to record this in terms of millimeters, and to reproduce this measurement in full dentures at a later date. The terminology of the initial report[1] has been simplified to describe the same method of measuring vertical dimension. The revision of the dental terminology helps to avoid the present-day confusion in the study of vertical dimension and jaw relationship.

It is now possible to prove scientifically by the speaking method that vertical dimension must not be increased.[2] Those dentists who reconstruct the occlusion of patients will generally find that failures can be avoided by completing the treatment without the increase of vertical dimension. If this dimension should be increased, this treatment must be based on scientific proof and not on the opinion of the operator.

THE SPEAKING METHOD

The method of measuring vertical dimension is discussed in order to present the practical means for its use. The patient is seated in an upright position (Fig. 1) without the use of the headrest, with the eyes forward, and the occlusal surfaces of the upper posterior teeth parallel to the floor. The measurement is taken under identical conditions of posture and vigor of speech. The head must not tilt forward or backward, and the patient should speak rapidly in a calm and relaxed manner. A particular observation must be made that the patient does not consciously control the movement of the mandible, as any variation from normal might affect the measurements.

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Direct the patient to close into centric occlusion, with the upper and lower teeth together in maximum occlusal contact. Draw the centric occlusion line (Fig. 2) with a sharp pencil on a lower anterior tooth at the horizontal level of the incisal edge of the opposing upper anterior tooth.

Have the patient say "yes," and while the phonetic sound *s* is being pronounced, draw the closest speaking line (Fig. 3) on the same lower anterior tooth

Fig. 1.—Position of patient when measuring vertical dimension with the speaking method.

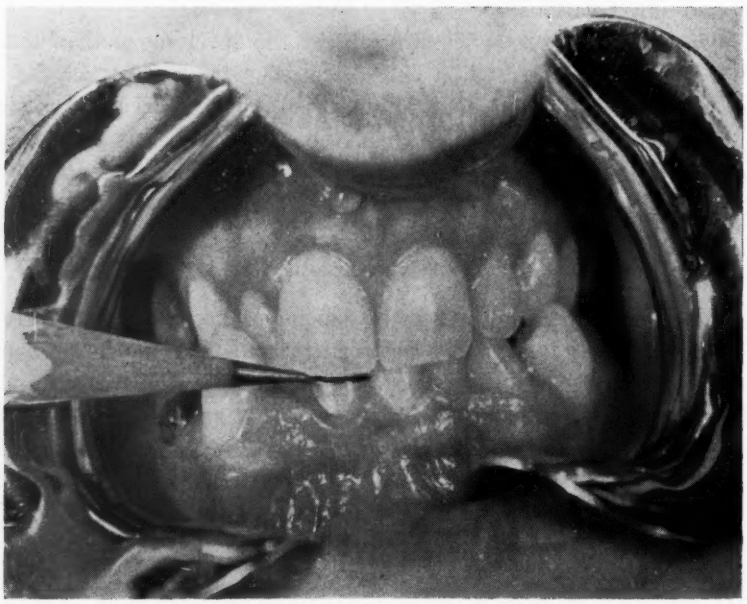

Fig. 2.—Marking the centric occlusion line on a lower anterior tooth while the teeth are closed together in centric occlusion.

at the horizontal level of the upper incisal edge. The distance between the centric occlusion line (lower line) and the closest speaking line (upper line) is called the closest speaking space. This closest speaking space is the measurement for vertical dimension.

In some patients, the mandible will move forward during the pronunciation of some or all speech sounds.[1,3] This forward movement will not affect the accuracy of the measurement because the same movement occurs, and the vertical distance between the lines is always remeasured in the same manner with both natural and artificial teeth.

Fig. 3.—Marking the closest speaking line while the patient pronounces a word with one of the sibilants, like *s* in *yes*. The distance between the (lower) centric occlusion line and the (upper) closest speaking line is the closest speaking space. This space is the measurement of vertical dimension.

The closest speaking space may vary in different individuals. In the series of patients examnied,[1] the measurements ranged from 0 to 10 mm., which proves that there is no such thing as "an average" in measuring vertical dimension. Measurement must be made with accuracy as it has been found that increasing the vertical dimension only one millimeter will cause discomfort to the patient.[2] The closest speaking space has been found to be constant in each individual, in patients observed since February, 1950. It is felt that the closest speaking space should be constant throughout life. Records are being kept to determine the accuracy of this supposition. This belief may be accounted for by the "all or none law" of muscle physiology which states that each muscle fiber is in maximum contraction during the stimulus of function. Because this system of measuring vertical dimension is based on physiologic function of muscles while used in speak-

ing under similar conditions, the same levels of the mandible are caused by maximum function of the specific muscle fibers involved.

Out of the 44 phonetic sounds of the English language, one or more of the six sibilants s, z, sh, zh, ch, and j in such words as ye*s*, bu*zz*, fi*sh*, mea*s*ure, *ch*ur*ch*, and *j*ud*g*e are the sounds which cause the closest level of the mandible to the maxilla while speaking, in 90 per cent of the cases surveyed. In the exceptional cases where other sounds caused the closest level, it was found that the sibilants caused a constant and accurate level of the mandible in relation to the maxilla. The remaining of the 44 phonetic sounds caused wider spaces between the mandible and the maxilla, but through experience of making over 10,000 measurements, it was found that these wider levels were not constant nor accurate and

Fig. 4.—Shows the centric occlusion of artificial dentures with no vertical overlap. The centril occlusion line is at the incisal edges of the lower anterior teeth of this edge-to-edge arrangement.

could not be relied upon as a guide to the measurement of vertical dimension. Therefore, to save time and be assured of accuracy, vertical dimension should be measured with only the six sibilants of the 44 phonetic sounds of the English language.

In some patients, it is found that not all six sibilants will cause the closest level of the mandible to the maxilla while speaking. Only one or more sounds of this group will cause the closest level. If such is the case, the sound or sounds with its measurement of the closest speaking space in terms of millimeters should be recorded on the patient's record.

The closest speaking line should first be located and marked by the use of individual words containing the six sibilants as described above. In order to be

certain the patient did not control the movements of the mandible consciously, it is advisable to check further for accuracy. Have the patient say "Mississippi" which contains many sibilants. Then a magazine is given to the patient to read aloud. While the sibilants of the talking or reading matter are pronounced, it should be noted whether the incisal edges of the upper tooth coincide with the closest speaking line drawn on the lower tooth as determined by the use of individual words. If there is variation in the position of the closest speaking line, it is generally due to a voluntary muscular control of the lower jaw. When the patient speaks or reads rapidly, the function of the mandible is unconsciously accurate because all conscious control of the mandible is eliminated.

Fig. 5.—Shows the measurement of the closest speaking space when there is a space between the centric occlusion line (lower incisal edge) and the closest speaking line (upper incisal edge).

Whenever lines cannot be drawn on the lower anterior tooth due to space between the upper and lower teeth, Figs. 4 and 5 show how the closest speaking space is measured. In this example, there is no vertical overlap in the dentition which is to be measured for its closest speaking space. The centric occlusion line of this edge-to-edge relationship is at the incisal edges of the lower anterior teeth. The closest speaking line is at the incisal edges of the upper anterior teeth. The closest speaking space is the distance between these two lines as measured.

The closest speaking space as measured in the natural dentition must be reproduced in full dentures after the loss of the remaining natural teeth.

When we build full dentures for patients without pre-extraction records of the closest speaking space, we are back again to guessing at the proper vertical dimension. With an understanding of the speaking method and its closest speaking

space, we can more intelligently approximate the vertical dimension, and eventually record the patient's natural vertical dimension after the shrinkage of the alveolar ridges or wear of the artificial teeth. The accurate closest speaking space is eventually obtained by measuring at intervals until the patient is free of sore spots and is relatively comfortable.

It is always advisable to measure the closest speaking space of all full denture patients at least once a year until it is found that there is an end to discomfort, and perhaps to alveolar shrinkage or wear of the artificial teeth. If the closest speaking space remains constant in the full dentures, it is simple to duplicate this same vertical dimension when registering the maxillo-mandibular relation of new dentures, with the additional help of tattoo dots on the alveolar ridges.[4]

The speaking method for measuring vertical dimension must not be confused with other methods. It is a physiologic phonetic method based on the movement of the mandible while the patient speaks. It is based on the science of phonetics used to teach the deaf and hard of hearing to speak, and is newly applied to dentistry in order to measure the distance between the upper and lower jaws.

The closest speaking space to measure the vertical dimension in this speaking method must not be confused with the free-way space of the centric relation method.[5,6] The free-way space establishes vertical dimension when the muscles involved are at *complete rest,* and the mandible is in its rest position. The closest speaking space measures vertical dimension when the mandible and muscles involved are in the active *full function* of speech. Experience has shown that the measurements for the free-way space and the closest speaking space of the same patients are generally *not* the same.

I have found it difficult to measure the free-way space accurately. It can, at times, consume hours of checking and rechecking and may require cephalographic roentgenograms. The measurements are not only difficult, but lead to inaccuracy and its measurement and reproduction in full dentures is in terms of "an average." The measurement of vertical dimension with the closest speaking space is simple and consumes only minutes instead of hours in checking and rechecking. It is practical because the measurement can be made by the dentist in his own office in less than one minute. It is scientific, and the measurement is made with accuracy for each patient. It is recorded on that patient's record to give us the most practical, scientific, and accurate method of measuring vertical dimension of all our patients for present and future use.

SUMMARY

The speaking method of measuring vertical dimension is a physiologic phonetic method which measures vertical dimension by means of the closest speaking space. This space is measured *before* the loss of the remaining natural teeth to give us the patient's natural vertical dimension which can be recorded and used at later dates.

The same closest speaking space should be reproduced in full dentures as is found in the natural dentition. This space is also the means of proving that vertical dimension must not be increased.

It is advisable to measure and record the closest speaking space of all patients after they are past 20 years of age, for possible use in later years. For example, if we should feel that a certain patient might need occlusal reconstruction the measurement of the closest speaking space can be made which can be compared to the space existing in earlier years. If this space should be larger during later years in life, it could be assumed that the vertical dimension was decreased, and treatment needed to increase the vertical dimension with occlusal reconstruction. This is an assumption based on the hope and feeling that the speaking method with its closest speaking space will prove constant throughout life, as records seem to indicate at the present time.

The measurement of vertical dimension by use of the speaking method with its closest speaking space has been found in my experience to be the missing link in successful full denture construction. It will prove most valuable to dentists doing occlusal reconstruction and to periodontists in the treatment of their patients.

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THE PROBLEM OF "THE CLICKING JAW"

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IT IS not many years since the treatment of lesions of the temporomandibular joint was regarded as the exclusive province of general and orthopedic surgeons. A growing appreciation in recent years of the importance of dental factors in the etiology of many of these conditions is at last resulting in the direction of these cases to the dental surgeon.

In many of the American publications on this subject the emphasis has been on the auditory symptoms which are believed to result from lesions of the temporomandibular joint. In my experience cases in which there are auditory symptoms are rare. The only cases encountered so far have been undoubted examples of otosclerosis. The purpose of this paper is to consider more closely the symptoms which definitely accompany disorders of the temporomandibular joint, in an endeavor to show the mechanism of their production and indicate a rational approach to their prevention and treatment.

SYMPTOMATOLOGY AND CLINICAL FINDINGS

In a series of consecutive cases the patients may be grouped according to their presenting symptoms, as follows: (1) Painless clicking during the opening phase. (2) Intermittent "locking" during which the opening is temporarily limited to about one fingerbreadth and usually accompanied by pain. (3) Limitation of opening with pain with a history of previous symptoms. (4) Limitation of opening with pain without previous symptoms. (5) Clicking, or, more accurately, jolting, at maximum opening and again at the beginning of the closing phase. (6) A combination of (1) or (2) with (5).

A typical patient in the first group is in the late teens or early twenties, with a history that the clicking began suddenly and spontaneously, or that it came on after some injury. The noise is quite often loud and may be audible to others as well as to the patient. It usually occurs when the mouth is about half-way open, but it may occur anywhere from quite early to almost the end of the opening movement. The patient is aware of a feeling of obstruction during the movement of opening, the click occurring as the obstruction is overcome. The rest of the opening movement and the whole of the closing movement are free of symptoms. Care-

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ful palpation or ausculation over the joint reveals that in addition to the loud noise during opening there is a faint click during the final 2 to 3 mm. of the closing movement.

In the majority of cases there is a deep overbite resembling that of Angle's Class II, Division 2. Very often some or all of the molars have been lost. In some cases with apparently well-formed dental arches, the first molars have been lost

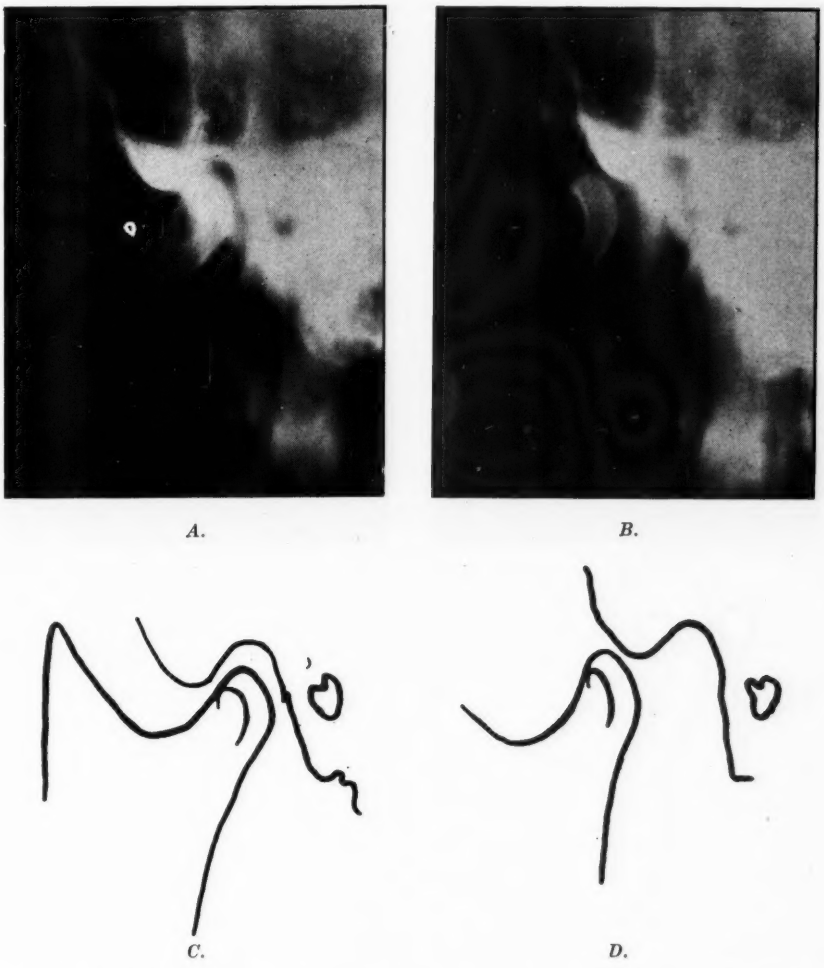

Fig 1.—Tomographic sagittal sections (with tracings) of a normal temporomandibular joint showing the relationship of the condylar head to the articular eminence in (*A*) the closed, and (*B*) the open position.

early to obviate crowding, and this appears to be responsible for the deep vertical overlap. Sometimes there is a single dental factor such as a misplaced tooth, in an otherwise normal dental arch, which prevents the teeth coming together into their normal occlusal relationship. In nearly all except these last instances the free-way space is larger than normal. The term free-way space denotes the difference be-

tween the intermaxillary distance in the incisor region when the mandible is in the rest position and when the teeth are in occlusion.

Radiographically, the condyle appears to be posterior to its normal position and there is a backward movement of the condyle as the mandible moves from the rest position into the position of occlusion (Figs. 1 and 2).

A striking clinical feature of this type of case is that if the teeth are prevented from coming into occlusion by placing something between them, as by a thin rod held across the upper arch in the canine region, the clicking is eliminated.

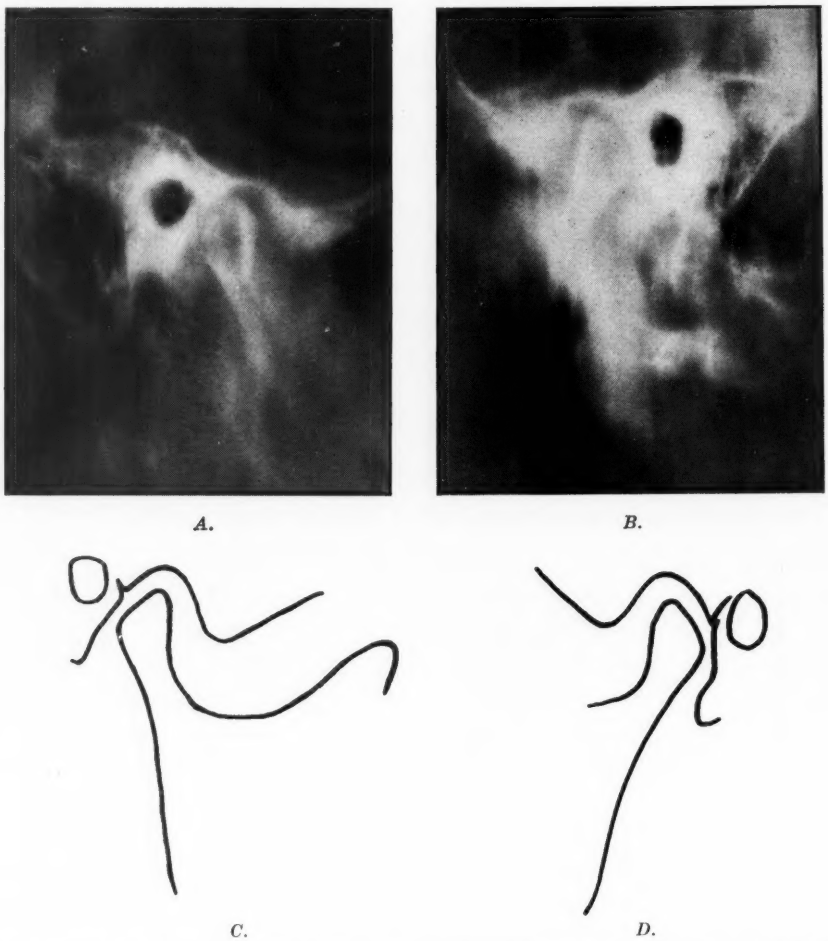

Fig. 2.—Note the backward displacement of both condyles in a typical case of painless clicking. Both sides are shown in the closed position.

Cases of this kind are not always free from pain. When the clicking has been present for a long time, and especially in women of neurotic type, pain over the area of the joint may be a feature. Occasionally some pain is present from the onset of clicking or it may even precede it.

A patient of the second group presenting himself for the first time complains that the jaw becomes locked, usually on waking, and for a time the mouth can

only be opened a few millimeters. He has severe pain over the affected joint which is made worse by attempts to open the mouth wider. By making some maneuver of the jaw, often by pressure over the joint, the patient is able to "unlock" the jaw and restore normal movement. The pain and tenderness persist for a time. In nearly all cases there is a history of clicking of the affected joint and when examined

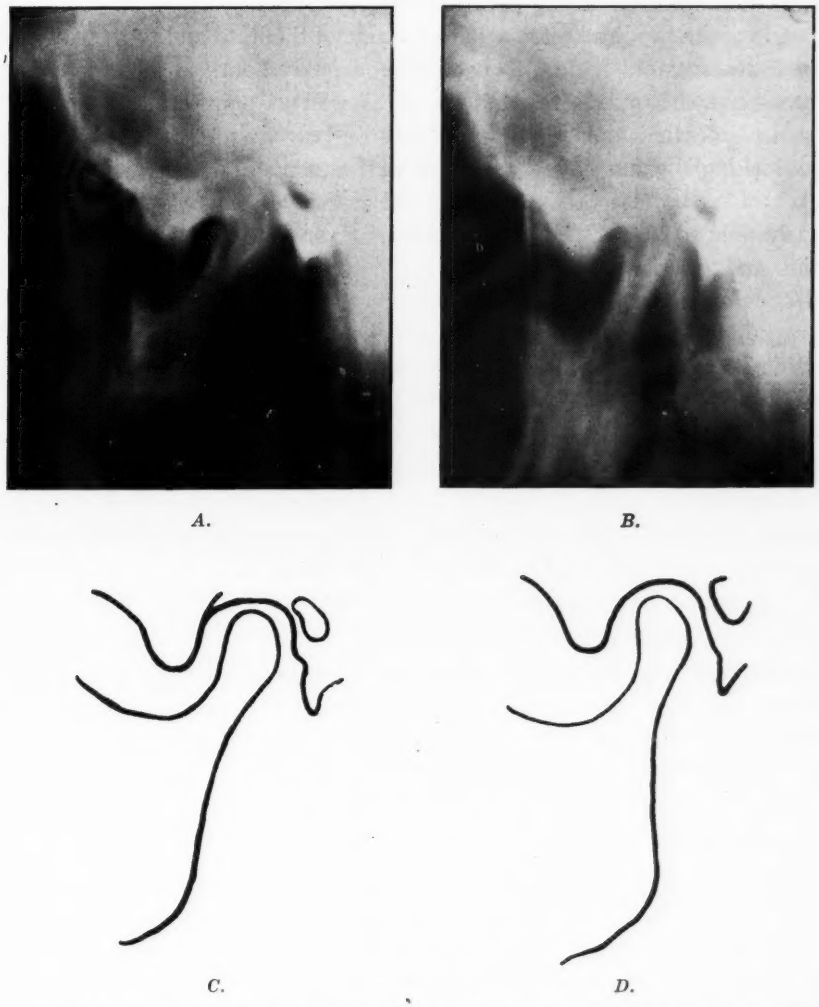

Fig. 3.—This patient had painful limitation of movement. Tomograms show absence of forward gliding of the condyle; (*A*) shows the closed and (*B*) the open position.

while the jaw is free the clinical findings are identical with those of the first group. The change in symptoms sometimes appears to have been spontaneous, but more often there is a history of some trauma, though this may have been slight. A slight blow on the chin, attempting to take a very large bite of a hard apple, "the free gratification of an inclination to yawn or sneeze," as Pringle[1] puts it, may have

brought about the change. Quite often there is a history of a recent dental extraction. This need not necessarily have been a difficult extraction of a lower molar, though that may well be the precipitating factor. On the contrary, when only one or two molars are in occlusion the loss of an upper molar may have a profound effect on jaw function, and precipitate symptoms.

A patient of the third group seen within a few days of the onset of symptoms complains of continuous aching pain centered over the affected joint radiating down to the angle of the jaw, and often also to the side of the head and to the ear, and occasionally to the mastoid region. The opening of the mouth is limited to about one fingerbreadth which makes eating difficult as well as painful. Usually there is a history of painless clicking for some months or years, with recent episodes of temporary "locking" which have become more frequent, and increasingly difficult to "unlock." On the last occasion the usual maneuver, by which the patient was previously able to "unlock" the jaw, failed. Examination reveals tenderness over the joint and often hyperesthesia over the temporal and parotid regions. The limited opening, which no longer causes any clicking, is accompanied by deviation of the mandible to the affected side. Lateral movement of the mandible to the opposite side is limited and increases the pain, while lateral movement towards the affected joint is usually full and without pain. Clearly there is an obstruction to the forward gliding movement of the condyle on the affected side. Careful observation of the teeth as they come into occlusion may reveal that this is accompanied by a lateral movement.

Roentgenograms (Fig. 3) show that the condyle, posteriorly displaced when the teeth are in occlusion, as in Group 1 cases, does not move forward when the mouth is opened. It sometimes descends vertically for a short distance, the joint space remaining appreciably wider than normal.

It is evident from the foregoing that the symptoms of the first three groups correspond to the first, second, and third stages of the same underlying process. Together they constitute what will be called Type I cases. It should be pointed out that although Type I cases usually go through all three stages they occasionally start at the second or even at the third. In this latter event it will be very difficult to distinguish the case from one belonging to the next group—Group 4.

Symptomatically, Group 4 cases are very similar to those of Group 3, but they are usually distinguishable by the absence of a history of clicking and by the absence of abnormalities of either teeth or jaws. Except for the limited forward gliding of the condyle on the affected side and some widening of the joint space, there is no radiographic abnormality.

The pain (which is severe) is sudden in onset, usually while eating, or it may follow a severe blow on the jaw. There may be slight swelling over the affected joint. Another distinctive feature of the Group 4 cases is the tendency to settle down spontaneously after a few weeks, leaving no abnormality.

Patients of the fifth group experience what must be described as a jolt of the mandible, sometimes accompanied by a noise which is more of a hollow knock than a click, just as maximal opening is reached and again as the closing movement com-

mences. It is usually bilateral, and the "jolts" on the two sides are not quite synchronous, but follow one another in rapid succession so that the mandible is seen to perform a small jerk to one side and then back to the midline. The simple test which eliminates clicking in the Type I case is without effect. Pain is not usually a feature of these cases, and many patients are unaware that their jaw movement is abnormal. Radiographically, they are indistinguishable from the normal in which the condyle rides well on to the anteroinferior surface of the articular eminence when the mouth is fully open.

The fourth and fifth groups are thus clinically distinct from each other and from the Type I cases and will be called Types II and III, respectively.

The sixth group has been included because cases in which the symptoms of either the first or second group are combined with those of the fifth are not uncommon. However, they possess most of the clinical features of the Type I case and run a similar course. The original six groups may thus be arranged as follows:

1. Painless clicking during opening phase	1st stage	Type I
2. Intermittent "locking"	2nd stage	Type I
3. Limitation of opening with pain with history of previous symptoms	3rd stage	Type I
4. Limitation of opening with pain without history of previous symptoms		Type II
5. Click or jolt occurring at maximum opening and again as closing phase begins		Type III
6. Combination of 5 with 1 or 2		Types III and I

THE MECHANISM OF CLICKING

Before considering the mechanism by which the symptoms are produced, it will be helpful to note certain structural features of the joint. In its simplest terms the temporomandibular articulation is a hinge joint in a movable socket; the fibrocartilaginous disc is attached very firmly to the condyle at its poles so that normally it follows the condyle in all its movements and allows only a simple hinge movement to occur in the lower compartment of the joint.

The upper surface of the disc articulates with the posteroinferior surface of the articular eminence. It is only the thin central part of the disc which is concerned in withstanding such pressure as is transmitted to the joint during biting and chewing. Behind and above this thin central part the disc is thickened and softer, forming a cap on the condyle. Behind this thickening the disc thins rapidly and is blended with the capsule. Below and anterior to the thin central part there is another less well-marked thickening of the disc to which part of the external pterygoid muscle is inserted through the capsule. The capsule allows considerable free forward gliding movement in the upper joint compartment during which the condyle rides not only on to the summit of the eminence, but often some distance on to its anteroinferior aspect. Some rotation of the condyle about its vertical axis and some lateral movement, the Bennett movement, is also possible.

The normal movement in opening the mouth is brought about by a combination of hinge movement in the lower compartment and forward gliding in the upper. It has been shown by Thompson[2] that the movement of the mandible from the position of occlusion to the rest position is a pure hinge movement. Beyond this point gliding movement is increasingly evident, becoming predominant as maximal open-

ing is approached. During closure this order is reversed and again the mandible passes from the rest position to the occlusal position by a pure hinge movement.

It is important to view the articulation of the mandible with the base of the skull as a single entity. Not only are the two mandibular joints coupled together, but the two complexes also articulate through the teeth attached to them. When the mouth is opened the mandibular joints, and muscles and ligaments attached to the mandible, as well as the force of gravity, determine the position and path of movement of the mandible. When the teeth are in contact, they, as it were, dictate the position of the mandible.

Because of the mutual effect of the articulation of the teeth and the mandibular joints during development a high degree of harmony normally results, so that when the mandible moves from the rest position to the occlusal position the teeth meet exactly in their correct relationship. It will be seen readily that conflict between the "needs" of the joints and the "dictates" of the dental articulation may arise. Thus pain caused by biting on the gum flap over an erupting wisdom tooth may compel the patient to adopt a "bite of comfort" in which the teeth are brought together with the mandible deviated to one side. An overerupted upper third molar tooth, when the lower is missing, may impinge on the distal aspect of the lower second molar and cause a forced lateral deviation of the mandible to the opposite side each time the teeth are brought into occlusion.

Loss of posterior teeth may allow the bite to close and cause the mandible as a whole to be forced in a backward direction by the action of the inclined planes of the incisors. Since the rest position of the mandible is virtually constant this closing of the bite results in an increase in the free-way space, and the movement of the mandible from the rest position to the occlusal position is no longer a pure hinge movement. The condyles are driven into a position above and behind their normal position in relation to the articular eminence. Only one condyle is affected when a unilateral cause is responsible, but, when the bite has closed, both are affected.

This forced displacement of the condyle occurs each time the teeth are brought together in biting and chewing. If growth and development of the condyle and teeth have not ceased, compensatory changes may occur to restore harmony. The fact that only a small proportion of people who have lost posterior teeth develop joint symptoms, suggests that such compensatory changes frequently occur. If only a single tooth or perhaps two teeth are responsible for the forced movement, the conflict may be resolved by the loosening of these teeth and the appearance of localized paradental disease. When the teeth do not give way and compensatory changes cannot occur, the condyle is forced into the abnormal position hundreds of times a day, and the structures of the joint are subjected to a constantly recurring strain. In patients who grind their teeth during sleep, there is no respite for the joint.

The joint itself must be regarded as an important link in the proprioceptive mechanism coordinating the action of the muscles of mastication. Any disturbance of the joint is therefore likely to interfere with muscular coordination and cause abnormal forces to be transmitted to the joint. This will tend to perpetuate and

even increase the joint disturbance. The use of only anterior teeth also imposes an added load on the joint.

As in other joints prolonged excessive stress and altered mechanics of the joint ultimately cause degenerative changes. In the temporomandibular joint, this leads to loosening of the attachments of the disc to the condyle. Only a slight injury, which would be quite without effect on the normal joint, is then needed to start the train of symptoms described in the Type I case.

With the attachment of the disc to condyle thus loosened, the disc is no longer compelled to follow the condyle when it moves into its abnormal position, so that during the final few millimeters of the closing movements the thickened upper part of the disc rotates forward to lie between the condyle and the posteroinferior surface of the eminence. This movement of the disc causes the faint click heard during this movement. In some people, it is actually possible to feel what is certainly the edge of the disc being thrust laterally and forward when this occurs.

When the mouth is opened, the normal relationship of the condyle and disc is not immediately restored, but the disc and condyle move together, both pulled by the external pterygoid, for a variable distance on to the posteroinferior surface of the articular eminence when pressure on the thick part of the disc and tension on its posterior attachment to the capsule causes the disc to slip back with a snap into its correct position on the condyle. Thereafter during the rest of the opening phase and all but the last two or three millimeters of the closing phase, the condyle and disc maintain their correct relationship. If this final two or three millimeter phase of the closing movement is prevented, the relationship of the condyle and disc is not disturbed, and both opening and closing movements are free from clicking. This is, of course, what happens in the simple clinical test mentioned earlier, and in treatment the aim is to provide some permanent means of preventing the abnormal final part of the closing movement.

Once the disc has been sufficiently loosened from the condyle for clicking to occur the possibility of further damage to the joint is greatly increased. Not only is the posterior part of the disc subjected to pressure which it is ill-fitted to withstand, but the disc and condyle undergo additional trauma each time the click is produced. These factors alone may be enough to cause a low-grade traumatic arthritis in the joint. Further loosening of the disc increases the difficulty of restoring the correct relationship of the disc to the condyle, after displacement, which inevitably leads to the symptoms of intermittent locking, the thick upper part of disc remaining temporarily in front of the condyle, acting as an obstruction to its forward movement.

It is a short step to the third stage where the locking has become permanent. The disc is then no longer a gliding socket for the condyle and even the hinge movement occurs in an abnormal socket ill-fitted for such a purpose. This represents a severe disturbance of the mechanism of the joint; not only will it give rise to pain in and around the joint, and to reflex pain particularly in the area of distribution of the auriculotemporal nerve which supplies the joint, but limitation of movement of the one joint will impose a severe additional burden on the other, which ultimately may also give rise to symptoms. The low-grade inflammatory process due

to the constant trauma to the soft tissues of the disorganized joint may also ultimately give rise to bony changes in the condyle. Clinically, the picture will then be one of osteoarthritis.

What happens in Type II where painful limitation of opening starts suddenly while eating, without previous symptoms, can only be guessed; perhaps as a result of some unguarded uncoordinated movement the disc gets severely nipped in some way, or more likely, as Professor Rushton has suggested to me, a villus of the synovial lining gets nipped in the joint. If there has been a severe blow on the jaw, the explanation is simple. Clinically, the result in any case is an acute traumatic arthritis with an effusion into the joint cavity or cavities. It has already been noted that in this type and in the painful stage of Type I, the mandible may make a lateral movement as the teeth come into occlusion. This must not be confused with the lateral movement caused by a misplaced tooth. The effusion and edema of the soft tissues within the joint have caused some separation of the joint surfaces and shifted the axis of rotation of the mandible. In other words the lateral movement is a manifestation of the lesion in the joint, not as in the other instance, its cause. It is clearly important to recognize this distinction and avoid the error of grinding the teeth to make them harmonize with the temporarily deranged joint. With rest the condition tends to settle down and return to normal.

In Type III the condition may be regarded as a subluxation of the joint. The condyle moves well beyond the summit of the articular eminence, but instead of doing so smoothly, as in many normal cases where the condyle reaches this point, it does so with a jerk. A similar jerk occurs when the condyle passes the summit of the eminence during closure. During the opening movement the elevator action of the muscles seems to be insufficiently inhibited, and the pull of the external pterygoid too strong; while in the closing movement the elevator parts act strongly before the retracting parts of the muscles have brought the condyle behind the summit of the eminence. Clearly a very high degree of coordination of muscle action is necessary to accomplish this part of the movement smoothly. A relatively slight injury, such as may be caused by dislocation during a dental extraction under general anesthesia, may well upset the delicate neuromuscular mechanism and start this jerky movement.

It must be mentioned in passing that some people can produce an impressively loud snap or click in their temporomandibular joints voluntarily. The mechanism by which this is done is very similar to that in the type under consideration, except that the muscular incoordination is deliberate. The mouth is opened wide so that the condyle is a little in front of the eminence. The elevator parts of the muscles are then made to act strongly a little before their retracting effect is brought into play. In this way the condyle is made to spring back as soon as it reaches the summit of the eminence.

Reverting to the involuntary condition, here again the abnormal movement is itself injurious to the structures of the joint and tends to perpetuate the trouble and

even make it progressively worse. This is particularly likely to occur when there is a large horizontal overlap of the upper over the lower incisor teeth, and the mandible must be protruded to its maximal extent when biting on the front teeth. In this position, the condyle is no longer firmly supported on or behind the summit of the eminence, and the joint structures are subjected to abnormal stress.

The condition may become a true luxation, or by weakening the attachment of disc to condyle may predispose to clicking of the first type described. Fortunately, the patient usually exercises sufficient care and avoids opening the mouth to its maximum extent and the progress of the condition is interrupted with, in some cases, a spontaneous return to normal.

TREATMENT

In Type I, should there be a normal free-way space, treatment consists in a search for, and elimination of, causes of a "bite of comfort" or a misplaced tooth causing a forced deviation of the mandible as the teeth come into occlusion. This is usually not very difficult, but in some cases it is worth while to adopt the procedure described by Lindblom[3] which he calls "bite analysis." It should be pointed out, however, that success with this procedure is entirely dependent on the accurate registration of the rest position of the mandible.

In Type I cases with a large free-way space, treatment consists in making a bite splint or bite plane which prevents the mandible from closing more than 2 mm. beyond the rest position. In this way, the forced backward movement of the mandible and condyles is prevented and in the majority of cases painless clicking is eliminated. It cannot be too strongly emphasized that this is not the same as bite opening; the object is rather to fill in the abnormal free-way space and restore the mandible to its correct working position.

If the lower molars are missing, a partial lower denture with extensions over the occlusal surfaces of the premolars can be used. If all the teeth are present the bite splint can be made to cover the occlusal surfaces of the upper molars and premolars. Such an appliance is better tolerated in the upper jaw and it interferes less with speech. At the stage of recording jaw relations in the construction of the splint or denture measurements are made between marks on the face, or better still, on the incisor teeth when the mandible is in the rest position. The occlusion rims are built up and trimmed to give fairly uniform contact and to prevent closure beyond the rest position. Then with only the surface of the wax softened the patient closes, biting very lightly a further 2 mm. into the wax. The patient must be sitting comfortably and relaxed with the head unsupported. The occlusion rim must be replaced after cooling, and the closing movement repeated several times to make sure that each time the teeth pass exactly into the same position as they come into contact with the wax without any lateral deviation. If the clicking is not eliminated the procedure should be repeated allowing only ½ to 1 mm. closure beyond the rest position. If, as sometimes happens, this still fails, or only partly succeeds in preventing clicking, one must on no account be tempted to build up the occlusion

beyond the rest position, as this may have disastrous results. The bite splint is processed in clear acrylic. A lingual or palatal bar is used to keep the appliance as small as possible. The occlusal surface of the splint is trimmed so that only a very shallow impression of the cusps of the opposing teeth remain. Such a bite splint should be worn all the time, and on no account left out at night. If after being worn for several months the appliance has proved successful, the question of some more permanent prosthesis must be considered. Whether this takes the form of a removable denture or overlay denture, or fixed bridges, it is as well to remove all misplaced tilted teeth from the opposing jaw, so that there is a reasonable chance of restoring a good articulation by making the prosthesis to replace these and other missing teeth, at the same time as the permanent replacement of the bite splint is made. This work is best carried out using an anatomic articulator with face-bow registration and using the temporary bite splint when mounting the study casts in the centric position.

So far the treatment of only those cases with painless clicking and intermittent locking has been considered. It is among these that dental treatment has the best prospect of success. This is particularly encouraging when it is realized that this is the early stage of a process which if left unchecked may lead to a serious condition for which, in many cases, only surgical treatment offers relief and that not without risk. Whenever possible, therefore, the case should be treated at this stage. It would be better still to spot what might be called the potential "clickers" before the symptoms start. Ideally, much could be done by well-planned orthodontic and prosthetic treatment to prevent a given individual from becoming even a potential case.

If a patient is seen shortly after the onset of painful limitation of movement, the third stage of Type I, it is worth while to attempt a maneuver such as that described by Pringle[1] to reduce the displacement of the disc. A general anesthetic may be needed for this. If this is successful, the mandible should be immobilized in the rest position for about two weeks and then treated as a first or second stage case.

It should be mentioned here that at the onset of this condition the patient may experience the severest pain. It is one of the few instances among these conditions where a course of shortwave diathermy to the joint and muscles affords relief.

If the maneuver just mentioned is not successful in restoring normal movement or the condition has been present for some time, the first step is to construct a bite-splint in precisely the same way as that already described, but with a smooth occlusal surface. This will not only prevent the forced movement of overclosure, but will eliminate all lateral stress and allow the mandible to take up its new position as edema within the joint settles down. In a proportion of cases this brings relief, and the patient becomes free from all except occasional pain and regains sufficient mobility in the joint to eat without undue difficulty. When this has been achieved the construction of a permanent appliance, on the lines already described, can be undertaken.

If after a reasonable trial of these measures, either the pain or the limitation of movement or both are unrelieved, surgical treatment must be contemplated.

The evaluation of the various forms of surgical treatment is beyond the scope of this paper; at the Maxillo-Facial Unit at East Grinstead, in cases of long standing, especially with severe limitation of movement or bony changes in the condyle, condylectomy has been found to give better results than extirpation of the disc. It is important to regain good movement in the false joint following condylectomy by using a training flange attached to a lower cast cap splint.

Extirpation of the disc probably has a place in the treatment of the early case, shortly after the onset of pain and limitation; but the tendency for symptoms to return with crepitation in the joint after some months or years cannot be ignored. In any case every effort must be made to establish a sound functional dental articulation after operation; not only to make the best of the new joint but to try to save the other joint from a similar fate.

For the Type II case—the acute traumatic arthritis—immobilization in the rest position, and a course of shortwave diathermy to the joint, insure speedy relief from pain and a more certain and rapid restoration of normal function than if the mandible is left free. Alternatively, if the patient is not willing to have his jaw immobilized, a bite splint with a smooth occlusal surface may be used. The splint is worn only until the pain has gone.

In the third type of case, if the subluxation is of a mild degree no treatment, beyond an injunction to the patient that he must avoid opening his mouth to the full extent, may be necessary. If there is a marked overjet of the incisor teeth it would be rational to correct this.

For the more severe case, there is a rather unattractive choice between several forms of surgical treatment and the use of a sclerosing agent injected in the joint. They all have as their objective the limitation of the forward gliding movement of the condyle, and they are all more or less successful in achieving this, whether it is by an osteoplastic operation to produce a bony stop on the summit of the eminence, or by dividing the attachment of the external pterygoid, or by making a fascial sling around the joint. But when it is recalled that a simple arthrotomy also produces limitation of movement of the joint, it is clearly difficult to assess the merits of a particular operation.

The use of a sclerosing agent injected into the joint as described by Schultze[4] has the merit of simplicity and freedom from the risk of injury to the facial nerve involved in any operative procedure on the joint. It cannot, however, be warmly recommended as it undoubtedly achieves its effect by causing an acute arthritis which results in adhesions within the joint as well as the periarticular fibrosis claimed for it by the originators of this treatment.

In this paper, the relatively common lesions of the temporomandibular joint have been considered. Only a brief reference has been made to the neurotic element which is often an important feature. Edentulous cases have not been dealt

with separately, as they do not differ essentially from those discussed. The relatively rare cases of gradual limitation of movement in elderly patients with senile osteoarthritic changes, and in younger patients with polyarthritis involving the temporomandibular joint, have not been considered.

I should like to express my indebtedness to the Nuffield Foundation which enabled me to visit the Scandinavian countries for studies on this subject. I am also deeply grateful to Sir William Kelsey Fry and Mr. Terence G. Ward for their help and encouragement in the preparation of this paper.

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THE FUNDAMENTALS OF ORAL PHYSIOLOGY AND THEIR PRACTICAL APPLICATION IN THE SECURING AND REPRODUCING OF RECORDS TO BE USED IN RESTORATIVE DENTISTRY

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THE PURPOSE of this paper is to offer an intelligent compromise of the methods of simulating jaw movements.

In order to avoid confusion and give ample treatment to a few of the important fundamentals, it will be necessary for us to accept certain facts without benefit of sufficient discussion. The first of these deals with the objective of restorative dentistry; more specifically with the objective of extensive restorations such as large partial dentures, fixed bridges or multiple inlays. We are concerned with the problem of articulation, which, without a doubt, is the basis for all our dental problems.

In recent years there has been more and more agreement on the role that articulation plays in dentistry. Evidence is ever mounting that most of our periodontal problems are strictly those of articulation. Prosthodontists are fully aware of the importance of articulation in their work. Orthodontists now are aware that their failures are due to malocclusion. It is difficult to comprehend the existence of so many varied conceptions when the goal seems to be a common one. Perhaps this is due to a lack of a basic concept of the fundamentals. The efforts of this paper will be directed towards the rationale of certain procedures in the securing of records of the jaw movements.

ASSUMPTIONS

Let us first assume that: (1) We believe in the importance of balanced articulation as a solution to our dental problem. (2) We accept the presence of cusps as a physiologic necessity for the existence of the supporting bone. (3) We accept the presence of cusps as a mechanical necessity in the mechanics of establishing a balanced articulation. (4) We accept the understanding that a balanced articulation is said to exist when all the cusps (including the articulating surfaces of the anterior teeth) are in perfect harmony with the patient's jaw movements, and that there exists a "continuing contact" of the cusps throughout the range dictated by the width of the contacting surfaces.

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I realize that many would take issue with some of these statements; however, it would take several long papers to fully explain these assumptions. Nevertheless, any discussion of these statements would have to reckon with the basic fundamentals which we are about to explore. Therefore, if you understand the basic fundamentals which we are to discuss, you will automatically fall into agreement with these assumptions.

It is logical that if we are to establish an articulation which is in harmony with the jaw movements we must know what these movements are. Assuming that by some magic we could accomplish a perfect articulation, we must know the specifications of the masticating apparatus.

In order to keep the confusion to a minimum, let us analyze each movement separately, and correlate these movements to a method of registering them. Also let us visualize the control or effect which each movement has on our pattern of articulation.

THE HINGE MOVEMENT

The first of these movements is the hingelike movement of the mandible. This movement is accomplished by a simple rotation of the condyles on the lower surfaces of the menisci. The hinge movement may take place at any point along the condyle path. This is possible because the meniscus can be moved along the slope of the glenoid fossa, and it is this action that is called the condyle path. Remember the upper part of the temporomandibular joint produces the condyle path; the lower compartment produces the hinge action.

What is the practical application of the hinge action of the joint? It is possible to locate the center of the hinge action in a practical way. By locating the center of rotation for each condyle and joining these with an imaginary line, we have what is known as the hinge axis. The hinge axis is an imaginary line joining the centers of rotation for each condyle. It is constant to the mandible and determines the arc of closure in any contacting position of the teeth. The practical importance of the hinge axis and a hinge axis transfer of casts to an articulator is of tremendous importance.

Without an axis mounting, (1) you cannot intelligently diagnose an articulation because the teeth on the casts will not meet the same as they do in the mouth. (2) You cannot check or prove a centric relation record. (3) You cannot accurately adjust an articulator to reproduce jaw movements. (4) You cannot fashion an articulation that has cusps meshing in the same arcs of closure as the patient.

To locate the hinge axis, a hinge axis bow is firmly attached to the lower jaw, and by trial and error the centers of rotation are located. The location of these centers is permanently marked on the patient's face. A third point is marked opposite the infraorbital notch. This third point, with the hinge axis points, establishes the axis-orbital plane. All our registrations are made with reference to this established plane. The face-bow transfers are made from these points. The upper cast is then transferred to an instrument in the same relation as the upper jaw is to the axis-orbital plane. By means of a wax checkbite, the lower cast is attached to the articulator. When the wax wafer is removed, the lower cast approaches

the upper cast on the same arc of closure as the lower jaw approaches the upper jaw. The diagnosis now can be made accurately.

Now we can check or prove the centric relation by securing another wax checkbite. This wax checkbite does not have to be of the exact same thickness as the previous one, because within practical limits the teeth on the casts will be traveling on the same arcs of closure due to the hinge axis mounting. A hinge axis mounting makes possible the checking or proving of centric relation records.

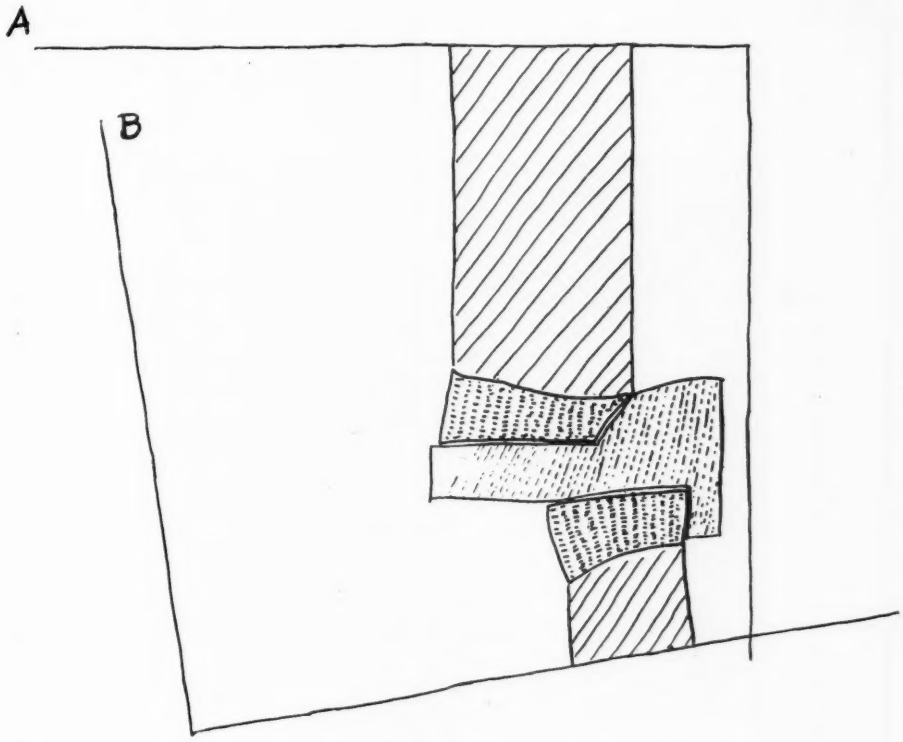

Fig. 1.—A wire frame is fixed to the upper cast. Another wire frame is attached to the lower cast. Point *A* represents centric position of the frames. By means of the protrusive checkbite a second point *B* is established. By joining points *A* and *B* with a line, the slant of the condyle path is established.

The adjustment of the articulator by means of checkbites or extraoral tracings will reproduce the positions and movements of the patient's dental mechanism. This is accomplished because the starting point (the hinge axis) is the same on the articulator as it is on the patient. Checkbites determine a fixed position or a path by means of two points (Fig. 1). If one of the points is not in the same starting position (such as the hinge axis), the second point determines a position which may or may not be related to the original position recorded on the patient.

In order to secure an accurate checkbite, it is often necessary to increase the interalveolar distance to free the anterior teeth. After setting the instrument by

means of a checkbite, we have to close the articulator. If the casts are not correctly related to the axis, they will be traveling through different arcs than the patient possesses. The only accurate point would be at the exact opening of the checkbite (Fig. 2). This is usually beyond the usable range for restorations and is worthless.

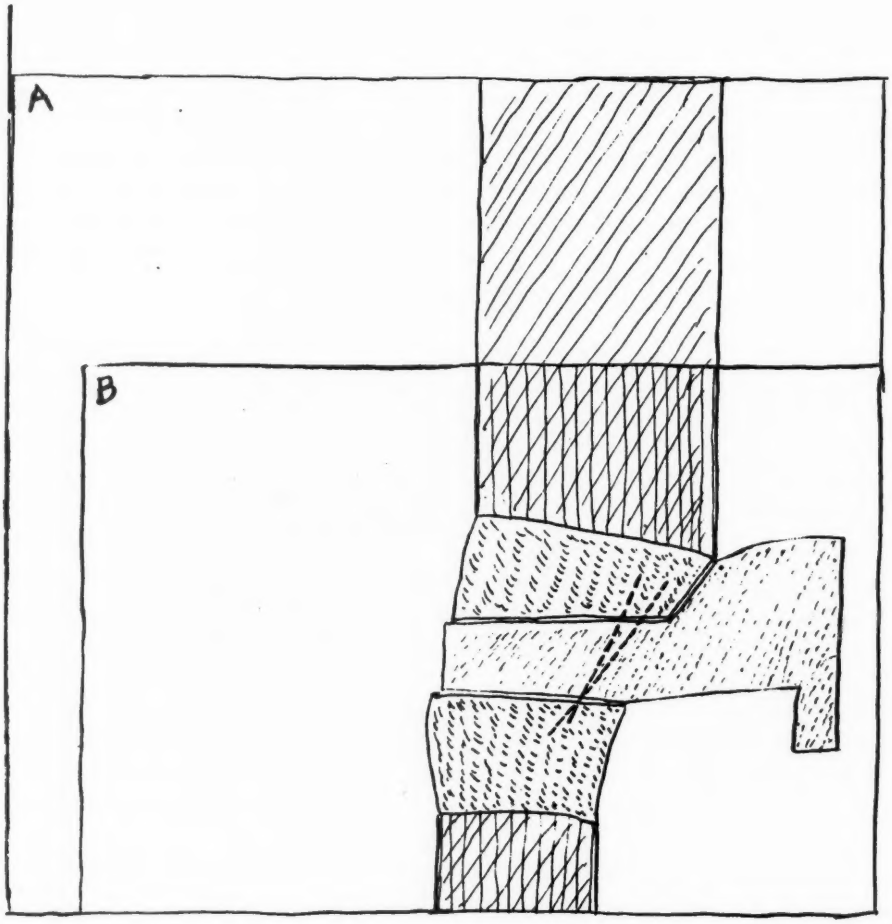

Fig. 2.—The upper and lower casts are shown superimposed on two wire frames. One set of casts is mounted with *A* as the center of rotation; the other with *B* as the center of rotation. Arcs have been scribed through the checkbite from these two centers. Notice the different paths followed by the lower model (teeth) as it traverses the thickness of the checkbite. Checkbites *not* mounted on the axis of rotation are inaccurate.

Without a hinge axis mounting, it is not possible to preserve the efforts at articulating the teeth and carry them through to a satisfactory completion. Often times changes have to be made in vertical dimensions, etc., and unless the changes are made on axis-mounted restorations, the changes will produce inaccuracies in the articulation.

CENTRIC RELATION

The next consideration is that of centric relation. Mandibular centricity is a relation of the lower jaw to the maxilla, and for the moment we may disregard the relations of teeth.

For all practical purposes, centric relation is the most retruded position into which the muscles of mastication can pull the mandible. Practically all the muscles of mastication are inserted anteriorly to the temporomandibular joint. In addition, the condyle makes contact with the glenoid fossa of the maxilla by means of the meniscus. The meniscus lies against the glenoid fossa which has an upward and backward inclination (Fig. 3).

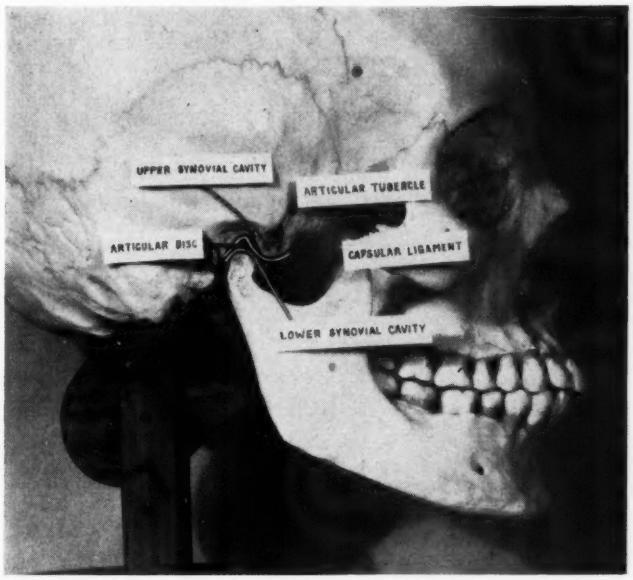

Fig. 3.—This sagittal section through the temporomandibular joint shows a "nesting" of the condyle in the tissue of the glenoid fossa. The hinge action takes place by a simple rotation of the condyle on the under surface of the articular disc. The condyle path is produced when the articular disc and the head of the condyle together slide down the glenoid fossa.

Contraction of the muscles of mastication tends to seat the head of the condyle in the most superior and posterior region of the fossa. We pointed out previously that the hinge action of the mandible could take place in any position along the condyle path. However, for practical purposes we located the axis in the most retruded position. This hinge action in the most retruded position is the centric relation. To transfer the centric relation, we merely have to relate the mandible to the maxilla in its most retruded position. This is exactly what we do when we secure a centric relation record or checkbite. The patient is guided into the hinge action, and a soft wax wafer is inserted between the maxilla and the mandible.

When the wax wafer is hard, we have the patient execute the hinge movement again, and if the indentations fit exactly, we assume that we have recorded the correct centric relation.

If we were to examine a sagittal section through the temporomandibular joint, we would view a "nesting" of the condyle in the tissue of the glenoid fossa. The meniscus would be interposed between the head of the condyle and the slope of the glenoid fossa. Posteriorly, the thickened rim of the meniscus rests against the strong fibrous tissue of the posterior part of the glenoid fossa, preventing any posterior displacement of the condyle. Posterior displacement is further prevented by the postglenoid lip (Fig. 3). The external pterygoid muscle also helps to prevent posterior displacement of the condyle. The entire joint is encapsulated by the strong temporomandibular ligament which is a part of the articular capsule which further tends to hold the nesting together (Fig. 4). The importance of this relation cannot be over emphasized. All the other registrations are related to the centric relation. If the centric relation record is incorrect, all other records will be worthless.

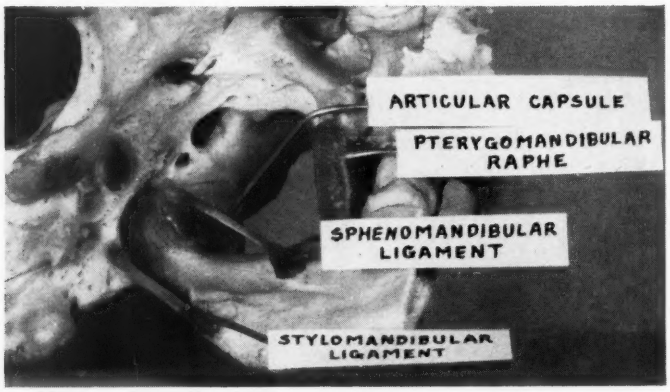

Fig. 4.—The various ligaments that limit the movements of the mandible. Note the articular capsule.

TOOTH RELATIONS AND CENTRIC RELATION

It is obvious that the relations of the teeth must be in harmony with the centric relation. They must contact evenly at the time that the muscles of mastication pull the mandible back to brace it against the meniscus, and in turn the glenoid fossa preparatory to the exertion of masticatory forces. Since the muscles can close the mandible in a hinge action any place along the condyle path, the cusps must make simultaneous contact. In order to make equal, simultaneous tooth contacts in all positions, the arc of closure must be the same in every position.

THE CONDYLE PATH

The next consideration is the movement of the condyle in the glenoid fossa. The condyle and the meniscus slide in the base of the glenoid fossa to produce what is known as the condyle path. The condyle path has an inclination and a curvature.

The inclination is measured in degrees—degrees in relation to a fixed plane, such as the axis-orbital plane. The curvature varies from a straight path to one having a curvature with a three-eighths inch radius. The inclination and curvature of the condyle path has a definite effect on the requirements of articulation. Assuming that all other factors remain the same, the steeper the condyle path, the steeper the

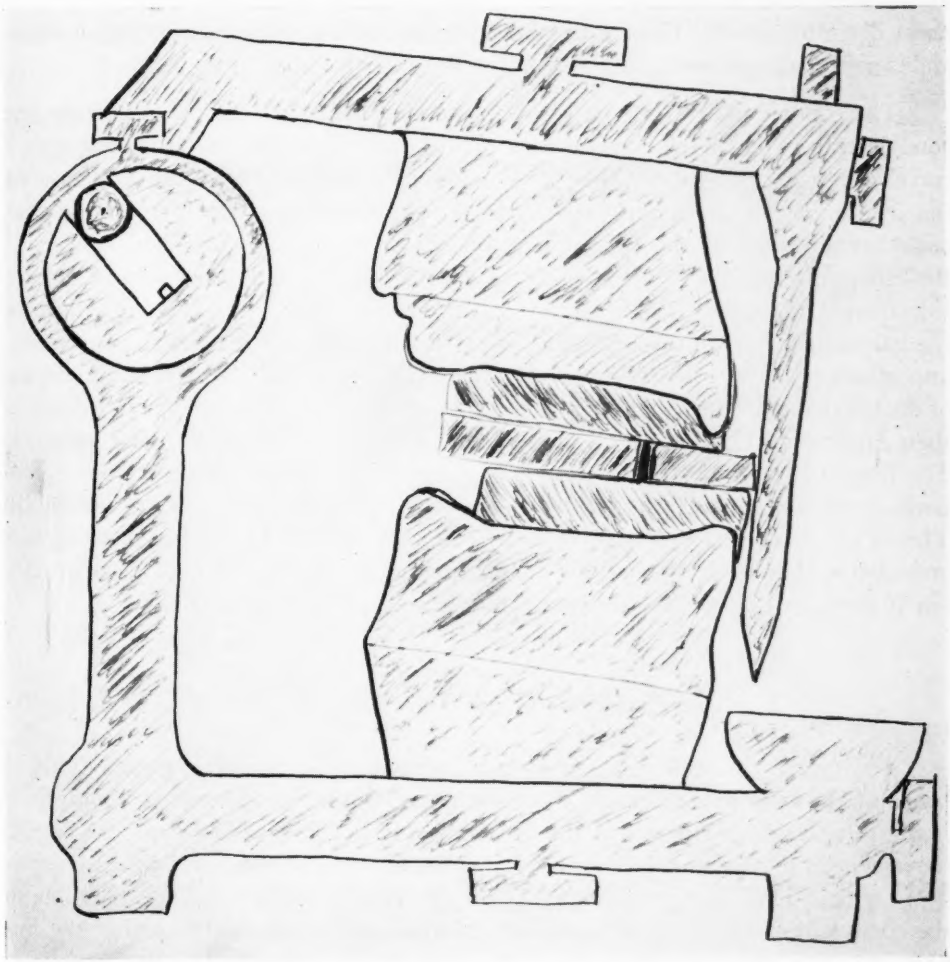

Fig. 5.—The protrusive checkbite in the articulator. Note that even though the upper member of the articulator moves backward, the path of travel is the same.

cusps required to produce a balanced articulation. In the same way, a greater curvature affects the individual cusps when all other conditions remain the same.

The slant of the condyle path can be recorded and duplicated on an articulator by means of a protrusive checkbite, provided the casts on the articulator have been mounted on the axis. The protrusive checkbite records the second point. The first point was established by the hinge axis mounting. Two points establish a line, and

so we can duplicate a protrusive path (See Fig. 1). The lower wire frame is moved to the protrusive position. The upper wire frame represents the centric position. A line joining these two points would be the protrusive path. On the articulator, the corresponding situation exists (Fig. 5). The apparent difference is due to the fact that the upper member of the articulator moves backward; however, the path of travel is the same. The curvature can only be recorded by means of an extraoral tracing or by a series of a great many checkbites taken in successive short distances apart. Failure to record the curvature produces a negative error and is not too dangerous.

The condyle path exerts its greatest effect on the balancing cusps because the condyle travels down the condyle path on the same side that the balancing cusps travel over each other. In other words, when the patient moves the jaw toward the working side, the condyle on that side merely rotates, or it may rotate and slide laterally through the Bennett path which we will discuss in detail later. At the same time that this happens on the working side, the condyle on the balancing side travels down the condyle path and over its curvature. In so doing it affects the balancing cusps on the balancing side. The balancing contacts are of extreme importance. These contacts are found on the lingual inclines of the buccal cusps of the lower teeth and the buccal inclines of the lingual cusps of the upper. Witness their importance by virtue of Nature's plan to resist forces against these surfaces. The lingual root of an upper molar is by far the largest and strongest root. The bone on the buccal side of the lower roots is the heaviest and most dense of all. This is not by accident. Usually the first area of marked absorption in traumatic articulation is the tissue around the lingual side of the upper molars. This is usually due to premature contacts of the balancing surfaces.

THE BENNETT MOVEMENT

The fourth component of jaw movement is the Bennett movement. This is probably the most important and least understood of all the movements. Simply, it is the side-to-side movement of the mandible. It is distinguished from the lateral movement in the anterior region which may be due to a simple rotation in the condyle region. The Bennett movement is a bodily side-to side-shift of the mandible in the condyle region. True, it is usually accompanied by some rotation, but the important part is the side movement of the condyle. In other words, the condyle is capable of sliding medially in the glenoid fossa as part of the masticatory movement. The reason for the importance of the Bennett movement is self evident if the movement itself is understood. The Bennett movement is the jaw movement that the patient uses to triturate food. This comminution of the food requires great force—the greatest used in mastication. In addition, this force is of a twisting nature with a tendency to produce strong lateral forces. The Bennett path or movement dictates the position of the working cusps. Because the Bennett movement is a side-to-side shearing action, the cusps must be fashioned in such a way that they will permit the movement of the cusps through the corresponding sulci. This enables

shearing of the food without lateral stresses. If the cusps are not in harmony with the Bennett movement, the forces of mastication become traumatic lateral forces which are very destructive to the supporting tissues. No one denies the importance of reducing lateral stresses. Unfortunately, this cannot be done by simply grinding away cusps as is so often advocated.

Perhaps the Bennett movement can be better understood if we study the anatomy that produces this movement (Fig. 6). The glenoid fossa, in addition to having an anterior curvature and inclination, also has a medial curvature and inclination. Medially, it is bounded by a bony structure called the inner curbing of the

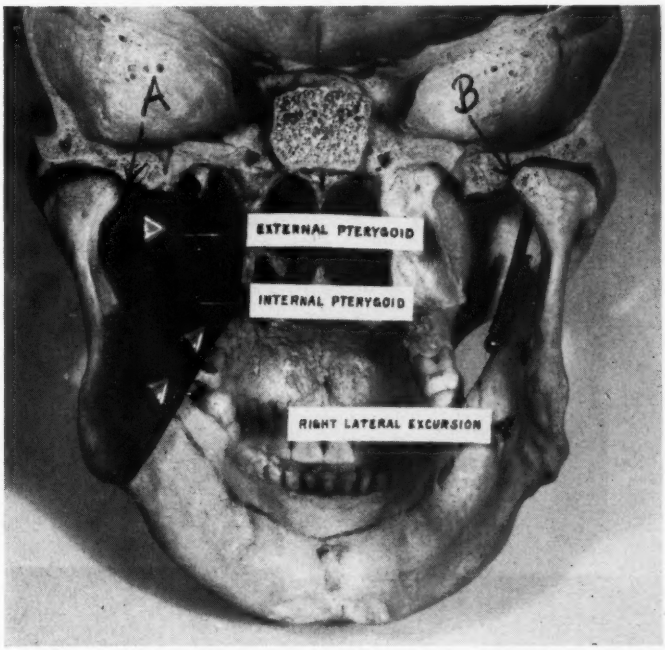

Fig. 6.—The inner curbing of the glenoid fossa is seen at *A* and *B*. Note the difference in the curvature and inclination on the two sides. This variation is responsible for the variations in the Bennett paths. The contraction of the internal pterygoid muscle causes the head of the condyle to take its guidance from the inner curbing of the fossa in lateral movements.

fossa. This inner curbing has a varying curvature and inclination. It is this variation in the formation of the curbing that produces the variation in the Bennett path. In order for the curbing to dictate a certain path, some force must motivate the head of the condyle against it. This motivation is produced by the internal pterygoid muscle (Fig. 7). By examining the origin and insertion of the internal pterygoid muscle one readily sees that its contraction tends to pull the mandible to the side. The amount and course that it traverses in this lateral (or medial) movement is dictated by the shape and prominence of the inner curbing. It becomes evi-

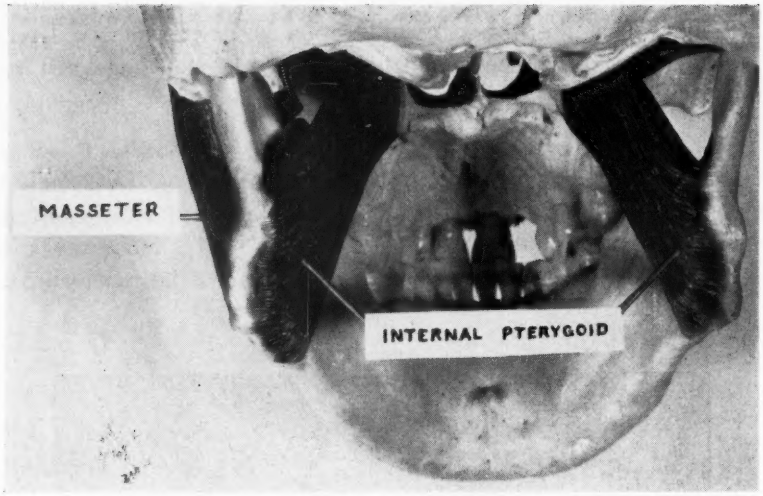

Fig. 7.—The internal pterygoid muscles have a definite medial inclination. Their alternate contraction causes the head of the condyle to ride against the inner curbing of the glenoid fossa. (Naturally, the other muscles of mastication are also working at the same time.)

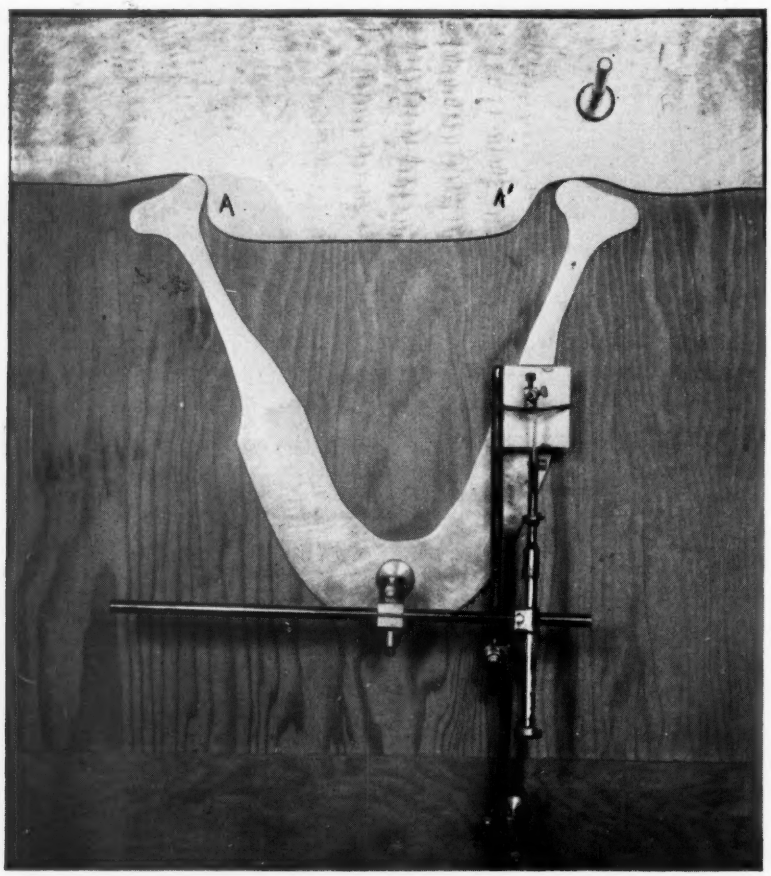

Fig. 8.—A model of a coronal section through the temporomandibular joints. Note the variations in the inner curbing of the glenoid fossae, *A, A'*.

dent then that if the jaw is going to be moved sideways in mastication along the Bennett path, the cusps must be in harmony with this movement if we are to avoid destructive lateral forces.

The model in Fig. 8 represents a coronal section through the temporomandibular joints. The inner curbings of the glenoid fossae are depicted one side different than the other. A tracing device was attached to record the lateral path of jaw movement (Fig. 9). In order to demonstrate the effect of less Bennett movement we inserted a shim against the inner curbing and took another tracing (Fig. 10).

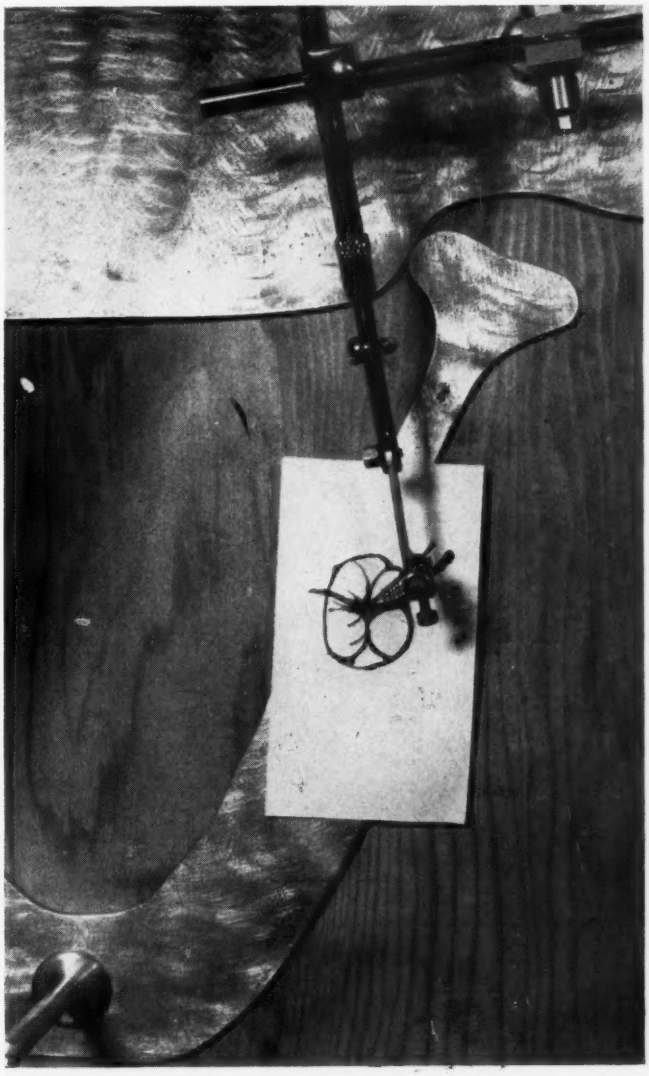

Fig. 9.—Tracing made with full Bennett movement taken into consideration.

The effect is self evident. Visualize cusps designed to function with one Bennett path when another was required. The lateral forces would be very destructive.

We have attempted to explain the important *unchangeable* factors with which we will have to cope in order to satisfactorily restore a proper articulation. Such

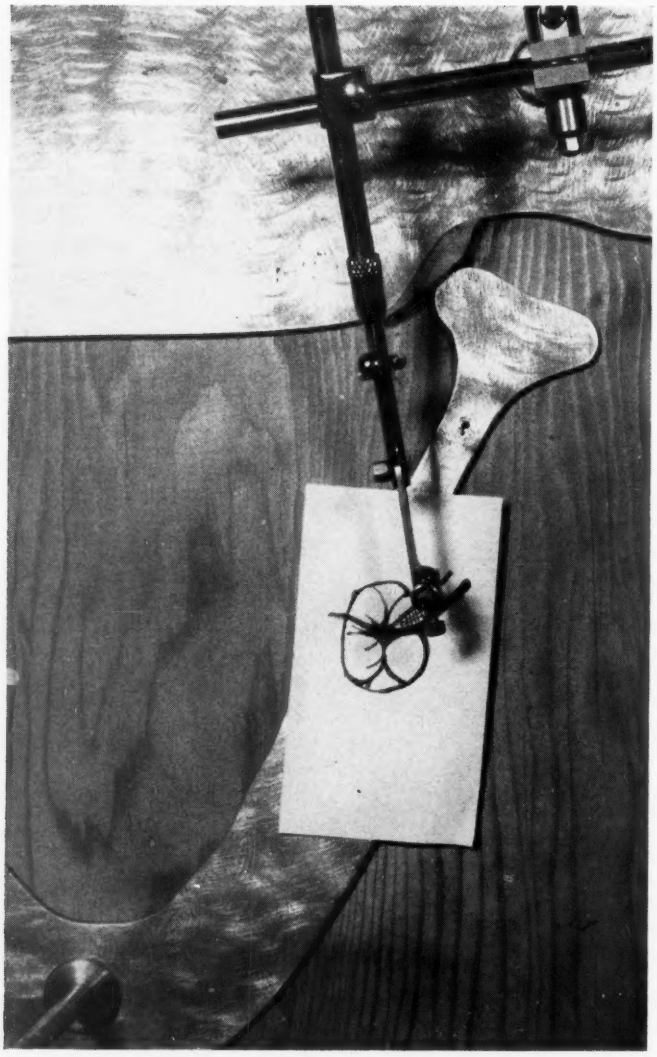

Fig. 10.—Tracing made with "shim" in place to simulate less Bennett movement. Notice the area on a molar that would be affected if the Bennett movement were not recorded.

factors as anterior guidance, curve of Spee, and plane of occlusion have purposely been omitted. Not that they are not important, but rather because to some degree they are alterable to suit our convenience. We have purposely dealt with factors which we must consider and over which we have absolutely no control. They are

there; the patient has no control over them; nor do we. It is our job to record them and make our restorations according to them, if the restorations are to be wholly successful.

TECHNIQUE

The problem immediately arises: How are we going to make these registrations? And how are we going to transpose these to an instrument that will enable us to conveniently construct the restorations?

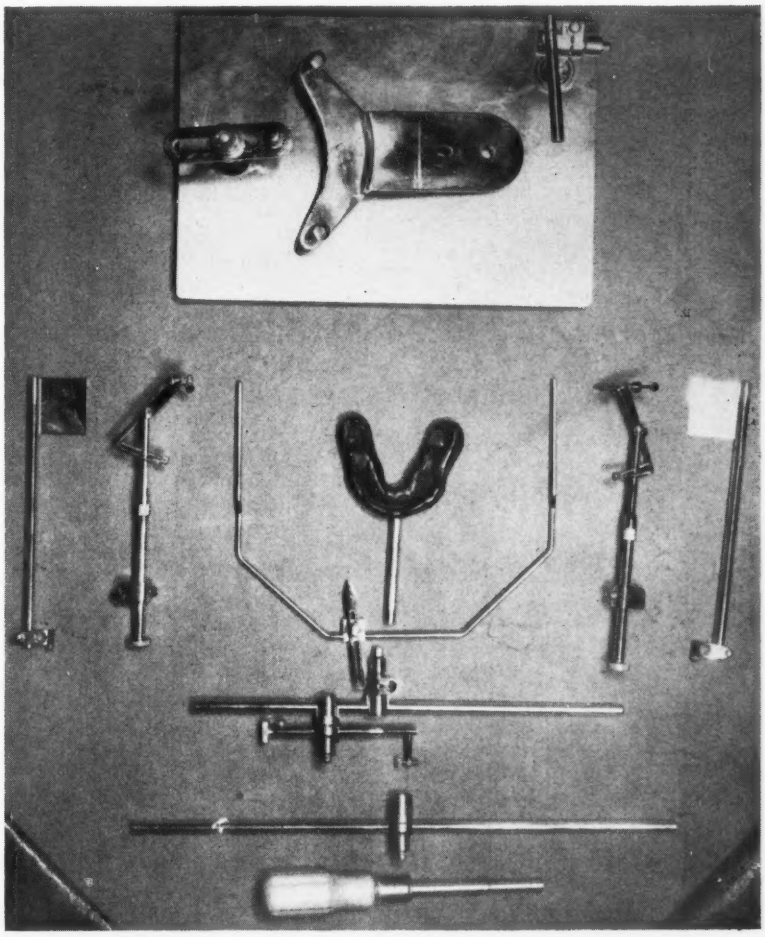

Fig. 11.—The apparatus necessary for locating the hinge axis and transferring the casts to an articulator.

LOCATION OF THE HINGE AXIS

The first step is the location of the hinge axis. This can be accomplished by means of any face-bow. However, with some it is a great deal simpler and more accurate. The important consideration is the fulfillment of the fundamental prin-

ciple. The apparatus necessary for locating the hinge axis and for transferring the casts to an articulator is shown in Fig. 11. The side arms of the face-bow have micrometer adjustments capable of definite minute movements.

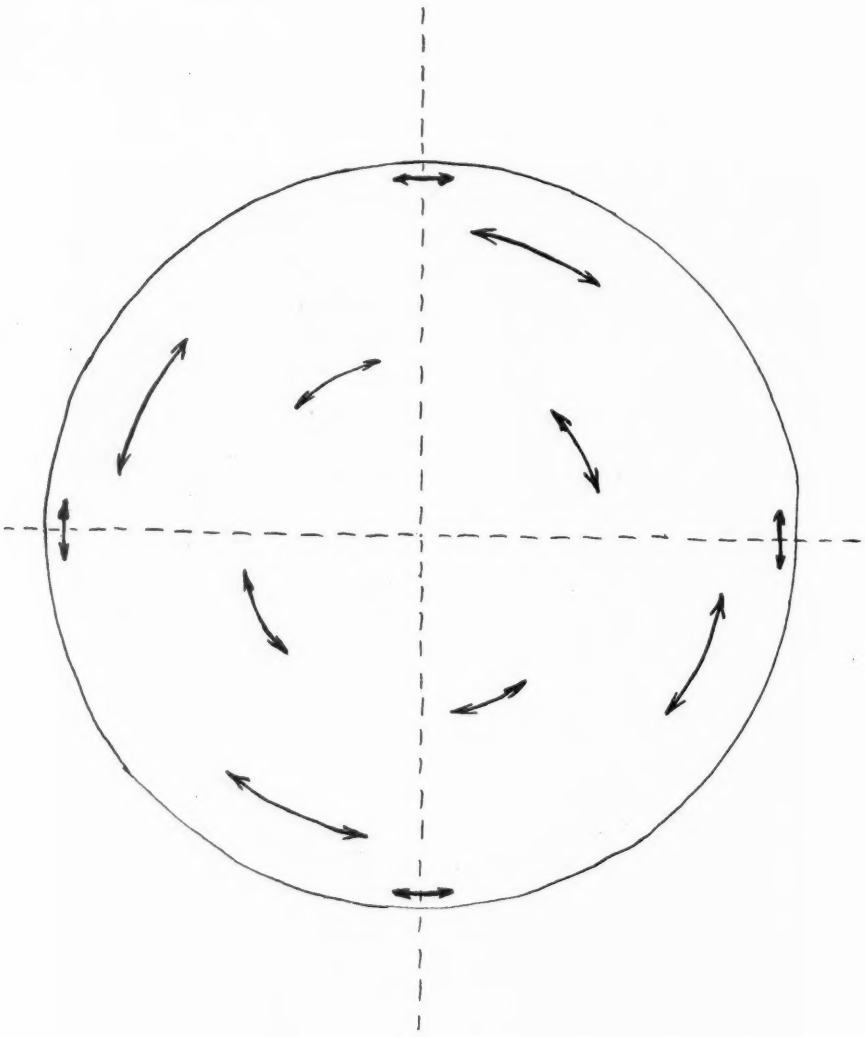

Fig. 12.—The pointer of the hinge axis bow will scribe a characteristic opening and closing arc depending upon its relation to the hinge axis when the tracing is made.

The axis is located by trial and error. The principle involved is the location of the center of rotation. Depending on how near the center of rotation, the stylus will make a characteristic arc (Fig. 12). By visualizing where that center is, we can find the point of no arcing and only rotation. This is the center of rotation. We must find the centers of vertical movement.

Having located the centers of rotations, we next use the face-bow in the conventional manner to accurately transfer the upper cast to an articulator so that the cast has the same relation to the axis of the articulator as the maxilla has to the axis of the mandible. The only exception is that we add the axis-orbital plane to the conventional face-bow. In order to facilitate this procedure we have designed a mounting frame which can be used with a slightly altered Hanau Model H or the Dentatus articulator. The alteration is simply the insertion of telescoping rods into the intercondylar rod (Fig. 13). This alteration enables the positioning of the face-bow in the exact position to carry through the accurate mounting of the upper cast.

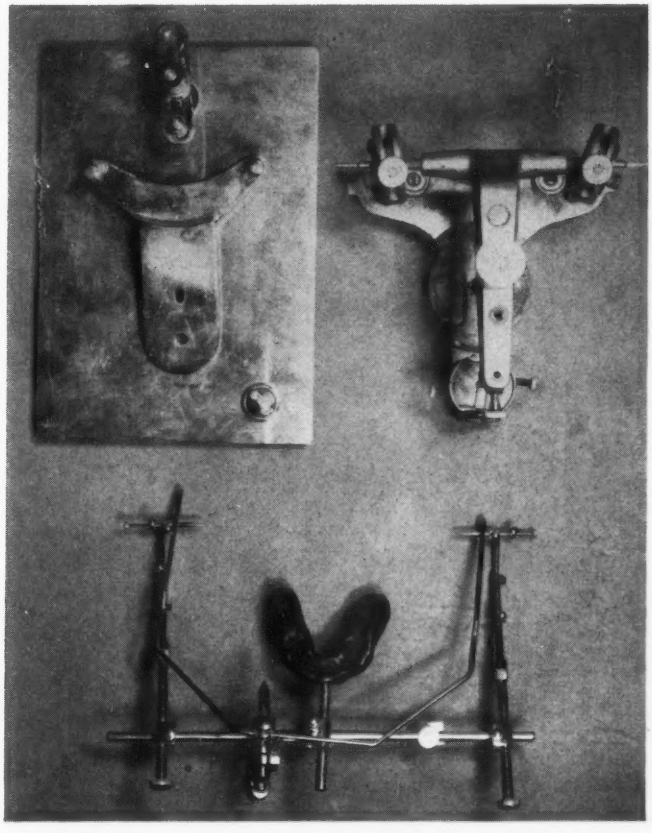

Fig. 13.—Mounting frame. Altered Hanau Model H articulator. Transfer bow with the axis-orbital indicator in place.

ARTICULATOR ADJUSTMENT

Having attached the upper cast to the articulator, we next must attach the lower cast to the articulator (Fig. 14). This is done by means of an accurate centric checkbite. This centric checkbite must fulfill the requisites of an accurate centric relation. After mounting the lower cast in its proper centric relation, we must

consider the setting of the articulator for the protrusive and the Bennett path. To accomplish this accurately, we must fashion special checkbite plates. Their design depends on the individual case. Suffice it to say, that if our records are to be exact, our checkbite plates must be carefully constructed and intelligently used.

If there are sufficient natural teeth remaining, the following procedure would be used. After the teeth are prepared, temporary inlays are made with nonparallel areas blocked out. The inlays are soldered to a piece of nickel silver so the inlays and plate can be removed from the cast and carried to the mouth without

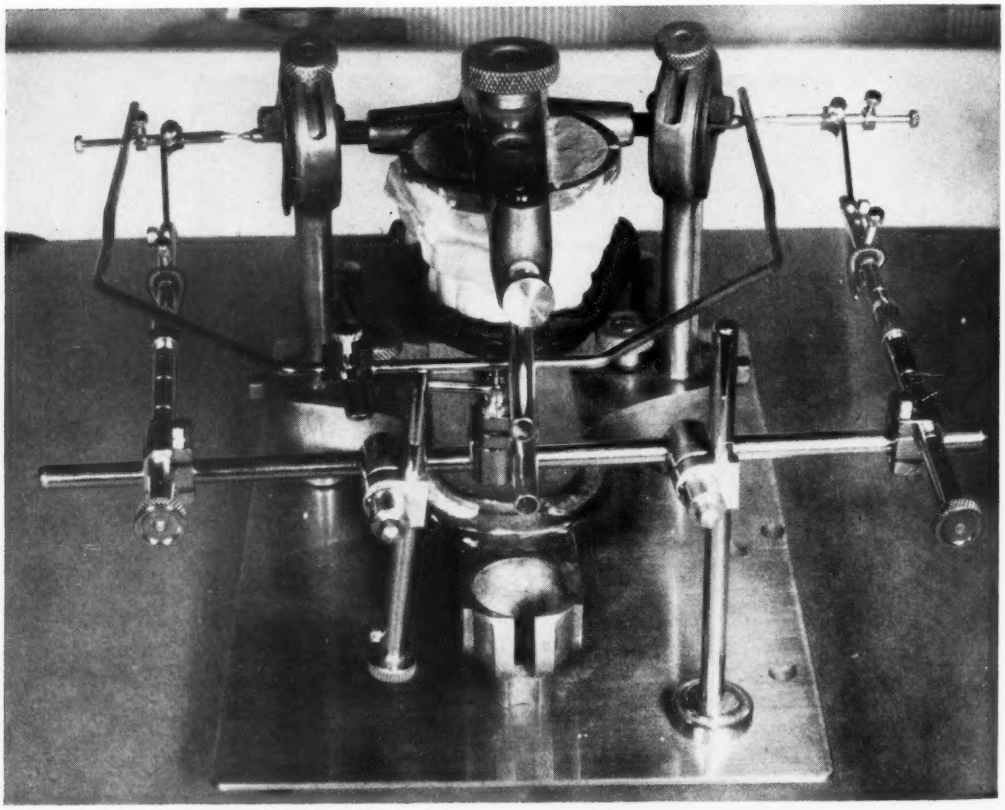

Fig. 14.—Transfer bow on mounting frame. The upper cast is attached to the upper member of the articulator. Note the transfer bow pins are opposite the hinge axis pointers of the articulator.

difficulty. The upper checkbite plate would be slightly curved buccolingually and sloped slightly upward posteriorly. The lower checkbite plate has a central bearing pin which eliminates any tooth interference.

An easier method of making checkbite plates is by means of a quick curing plastic. Block out the base of the cast and the undercuts with Plastocene. Adapt tin foil over this and into the cavity preparations. Place the soft plastic over the tin foil and press the plastic with a flat piece of metal to produce a smooth surface. Build up ridges to facilitate the seating of the checkbites. Drill and tap the

lower checkbite for a central bearing screw. When the checkbite plates are ready, and the casts properly mounted according to a hinge axis transfer and an accurate centric relation, the checkbite relations may be secured.

The lower surface of the upper checkbite plate is coated with a thin layer of red or black wax. Both checkbite plates are placed in the patient's mouth, and the patient is instructed to slide the lower jaw around in every direction. In a very few minutes, a spearhead or diamond is cut out of the wax. The upper checkbite plate is removed and a very small indentation is made along each wing of the spearhead with a small round bur. The indentations are made along the wing a little further back than the width of the contacting surfaces of the teeth. Usually this is about 3 or 4 mm. from the apex of the spearhead. Another indentation is made in

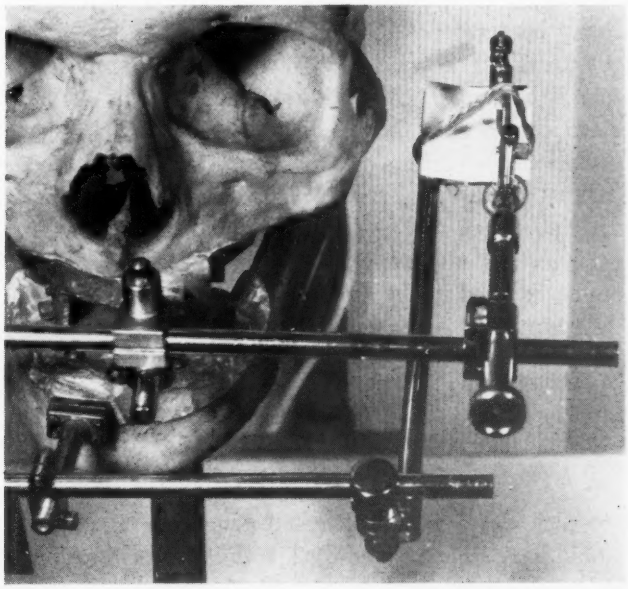

Fig. 15.—The hinge axis bow altered to make a Bennett path tracing for diagnosis of its curvature.

the middle of the spearhead in a position corresponding to the protrusive position of the mandible. This is usually 3 or 4 mm. from the apex. The purpose of these indentations is to help the patient hold his lower jaw in the recording position while the checkbite is made. This completes the preparations for securing the checkbite records for setting the articulator.

The patient is instructed to move his jaw into right lateral position. Some specially prepared quick-setting Gray Rock is squeezed between the checkbite plates. (Quick-setting Gray Rock is prepared by grinding some set Gray Rock. This powder is mixed with a little water and then the regular Gray Rock is mixed with it. By altering the amount of powdered Gray Rock, the setting time can be

altered to suit each individual's need.) The left lateral checkbite and the protrusive checkbite are secured in the same way.

The adjustment of the articulator is a routine checkbite setting. Each checkbite is assembled in turn, and the adjustments on the articulator are made for each position. Note that because of the design of the Model H or Dentatus it will be necessary to record the condylar inclinations for both protrusive and lateral positions. There usually is a difference between these two readings, and the articulator settings will have to be changed as the teeth are arranged into articulation for the lateral and then the protrusive positions. The Bennett adjustment is set at the same time as the lateral condylar inclination is set.

THE ARTICULATION

Having completed the setting of the instrument, the adjustment or carving of the articulation may be developed. Wax is applied to the cavity preparations and to the edentulous areas. The wax is divided into the approximate widths of the teeth, and carving is begun. By the addition and removal of wax in the various areas, the cusps are formed until the articulation begins to take shape.

The tooth relations in various jaw positions must be checked as the carving proceeds. When that "continuing contact" of the articulating surfaces of the teeth is established, the individual patterns are separated, and the margins are adapted prior to spruing, investing, and casting. When this is completed and the castings are made, they must be tried in the mouth. Due to many considerations, it is necessary to make remount casts of the restorations and examine the articulation on the articulator. These remount impressions are made with a combination of modeling compound and hydrocolloid to produce an impression into which the restorations can be accurately seated.

THE FINAL ADJUSTMENTS

If I were to pick out a single technical procedure as the most important, I believe that it would have to be this one. The finished restorations must be related to each other and to the masticating mechanism because that is where they have to work. When the corrections have been made on the articulator, the restorations are placed in the mouth, and certain things will be observed. Depending on the type of Bennett movement which the patient has, we may notice some interference in the cuspal positions. It becomes necessary to accommodate for these interferences. They are due to the fact that the patient's Bennett path may be curved, and with checkbites we are able to record only positional relations and to establish straight guides on the articulator. However, by careful spot grinding in most of these cases, we are able to correct this slight inaccuracy. It is necessary to visualize the type of Bennett movement. This can be done by obtaining a simple Bennett tracing by means of the hinge axis bow used as follows: The hinge axis bow side arm is attached to the upper clutch. A waxed surface on the mirror of the flag attached to the lower clutch is brought into contact with the stylus. The patient is instructed to move the jaw forward, to one side, and then to the other. A characteristic tracing will be obtained (Fig. 15).

By means of the tracing, the registrations of the Bennett path can be seen. This makes it possible to see where the interferences will be. The interferences . . . *NOT THE CUSPS* . . . are carefully removed. In the majority of cases, very satisfactory results can be obtained.

Perhaps of all the fundamentals presented, one which has been implied but not specifically mentioned stands out above all others in importance. It is this fundamental that has more to do with the successful treatment of your dental problems, whether they be orthodontic, prosthodontic, periodontic, or joint disturbances. This fundamental is the treatment of the mouth as a complete entity.

The days of piecemeal, patch dentistry are numbered. We must treat the chewing mechanism, the whole chewing mechanism, if dentistry is to receive its justified recognition as a healing art.

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PHYSIOLOGIC STRESS-EQUALIZER

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FOR too long a period of time we have had the misconception that partial denture restorations are temporary replacements for missing teeth—an intermediate step for the short time that patients may go before losing their remaining natural teeth, and having to resort to full denture prosthesis. There is no scientific reason for this, because properly designed partial dentures are just as much precision restorations as inlays, crowns, and fixed bridges. In partial denture prosthesis, we should strive not only to replace all missing teeth in order to restore functional occlusion, but we should also attempt to preserve the remaining natural teeth and their surrounding tissues.

We have had consistently good results with partial dentures that are entirely tooth borne, and we will continue to do so, if we design and fabricate them to maintain maximum efficiency from a mechanical, biologic, and physiologic standpoint.

I will limit this discussion to the construction of the type of restoration which, in so many cases, has resulted in "headaches" for both the dentist and the patient. This is the extension saddle partial denture in which the support of the appliance depends upon the edentulous areas as well as the remaining natural teeth. If we construct an appliance that is rigid between the clasps on the abutment teeth and the saddle areas, the stresses on the abutment teeth rotate at the occlusal rests (fulcrum points) which results in early loosening and loss of the teeth. When we incorporate into these appliances a spring wire, ball, and socket, or similar type stress-breaker, the movements of the saddle covering the edentulous areas are unlimited in all directions. This causes excessive resorption of the mucosa and underlying bony structure due to trauma, and results in frequent rebasings or duplications in order to maintain the appliance in functional occlusion.

THE STRESS-EQUALIZER

Our problem, therefore, is to design a stress-equalizer* as an integral part of the partial denture that will enable the operator to limit the movement between the clasps on the abutment teeth and the free-end saddle to such a degree that the movement will be within the physiologic tolerance of the underlying tissues. The gingival

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*I prefer the term stress-equalizer to stress-breaker, because we are not only breaking the stress, but are attempting to equalize the stress between the abutment teeth and edentulous areas.

movement of the saddle areas of the denture should coincide with the displaceability of the soft tissues covering the edentulous areas. By no means should a stress-equalizer be used routinely on all extension saddle dentures. The indication or contraindication for its use should be at the discretion of the operator.

The basic requisites for an ideal stress-equalizer are as follows:

(1) The stress placed upon the abutment teeth and the edentulous areas should be equalized as closely as possible, so the work load for each will approach their physiologic tolerance.

(2) The extent of the movement of the saddle in relation to the abutment teeth should be controllable by the operator.

(3) The cost of material should be low. The materials needed are stainless steel matrix strips 0.0025, and an adapter plate, which can be constructed easily with

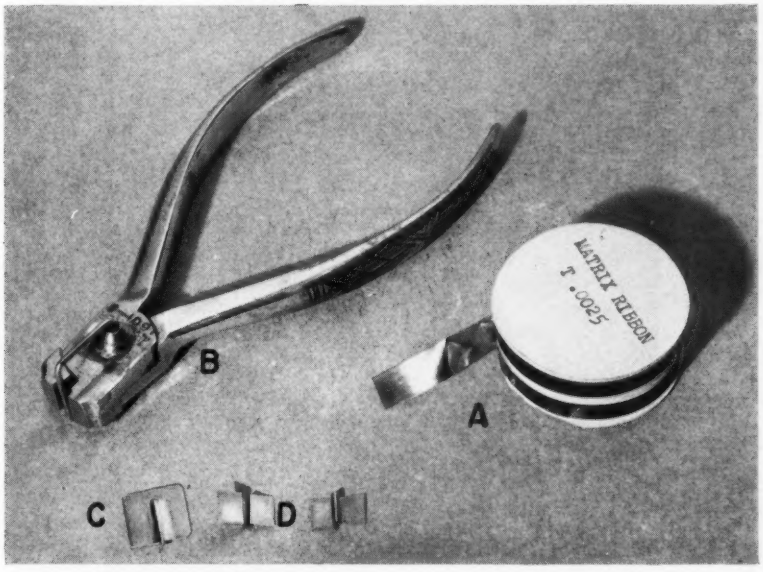

Fig. 1.—Armamentarium: *A*, stainless steel matrix, material 0.0025 thickness; *B*, pliers for adapting the matrix; *C*, backing for adapting the matrix; *D*, Pre formed matrices.

metal materials usually found in any dental office (Fig. 1). The adapter consists of a flat metal plate to which a post is soldered. The post should taper slightly from the occlusal to the gingival end. This will prevent the saddle areas from tilting due to the pull of sticky food. The adapter is almost identical to an interchangeable flat backing used in fixed bridgework. The difference is in the gauge and tapering of the post. This adapter is used to preform the matrix material to the desired shape with finger pressure and can be used indefinitely. Special pliers can be constructed for use in preforming the matrix more uniformly and easily (Fig. 1).

(4) The method of construction should consume as little time as possible. The incorporation of the preformed matrix to the wax pattern of the partial denture is accomplished in a matter of seconds, and the dissolving of the stainless steel in

muriatic acid after casting requires from ten to thirty minutes longer than pickling the casting. Therefore, the time used for the addition of the stress-equalizer to the partial denture is of no consequence to the operator or technician.

THE TECHNIQUE

In order to explain more fully the technique by which this equalizer is incorporated into the partial denture, I will briefly outline the steps in the construction of a lower bilateral extension saddle partial denture.

1. Make a full mouth digital and roentgenographic examination. Mount study casts for the location of clasps, rests, etc. Prepare the mouth for master impressions by performing all necessary alveoplasty, restoring all carious teeth with appropriate restorations, and creating suitable occlusal rest areas. The impressions may be made with the material and technique of your choice. I prefer to use a reversible hydrocolloid impression material for all partial dentures.

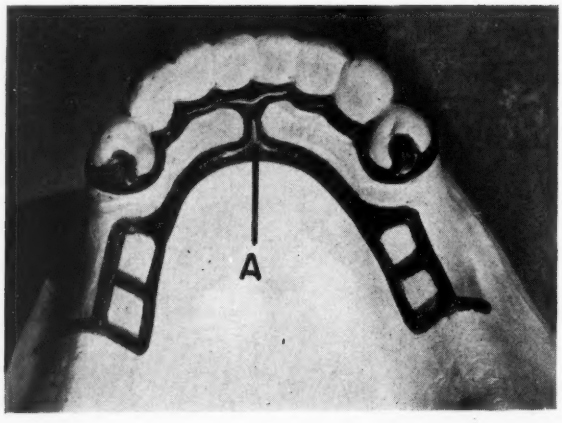

Fig. 2.—Refractory cast waxed: *A*, connecting bar between the lingual bar and the continuous clasp.

2. Survey, design, and wax the outline of the partial denture on the refractory cast, but do not connect the clasps to the lingual bar at the distal of the abutment teeth. The only connection between the clasps to the lingual bar and retentive lugs for acrylic is a bar from the center of the continuous clasp to the center of the lingual bar (Fig. 2).

3. Flow inlay wax into the male portion of the preformed matrix, add a drop of sticky wax, and lute to the distolingual area of the clasp. The matrix is placed in this position so as to create more space for setting the first artificial tooth into its correct position, without having to mutilate and weaken the mesial portion of the tooth. The matrix should be so placed that the male attachment is parallel to the long axis of the abutment tooth. This will distribute the work load in the direction of its greatest resistance to the force of mastication (Fig. 3).

4. The female portion of the equalizer is constructed by adapting one thickness of 26 gauge casting wax to the outer portion of the matrix, and attaching it to the acrylic retentive lugs of the lingual bar. The female attachment should be about 1 mm. shorter than the male attachment, both occlusally and gingivally. This will prevent a union between the two parts when the casting is made, by preventing the gold from flowing from one part to the other (Fig. 4). As an extra precautionary measure, to insure freedom of movement in the finished appliance, the gingival portion of the refractory cast may be scraped, so the matrix will be embedded slightly into the cast.

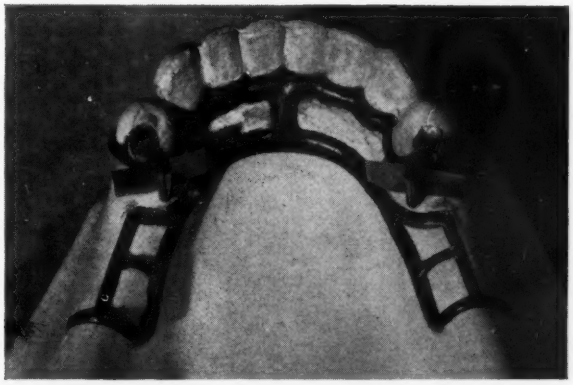

Fig. 3.—Male portion of the stress-equalizer luted to the clasp parallel to the long axis of the abutment tooth.

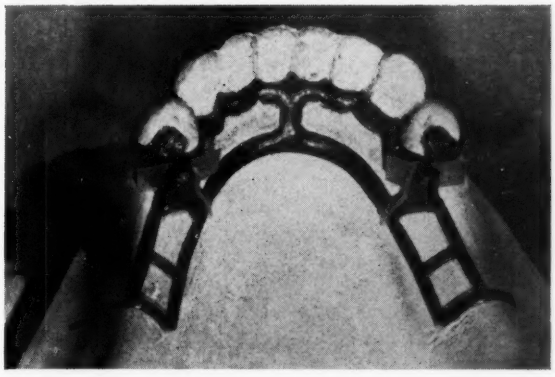

Fig. 4.—Female portion of the stress-equalizer waxed and trimmed to the desired size.

5. The excess flanges of the matrix are extended toward the buccal and lingual so they are engaged by the secondary investment, thereby holding the matrix in its predetermined position while wax elimination and casting is taking place (Fig. 4). Another pitfall to bear in mind is that, even though the fusing point of the stainless steel matrix is much higher than that of partial denture gold alloys, the mold must not be overheated in wax elimination, because the molten gold may penetrate the

matrix. This would result in fusion of the male and female attachments and make it impossible to obtain separation between the two.

6. Sprue, invest, and cast according to your technique of choice.

7. Clean the casting as much as possible mechanically, and pickle it in a hot solution of equal parts of muriatic acid and water. After ten to thirty minutes, the stainless steel matrix will be completely dissolved, leaving the male and female

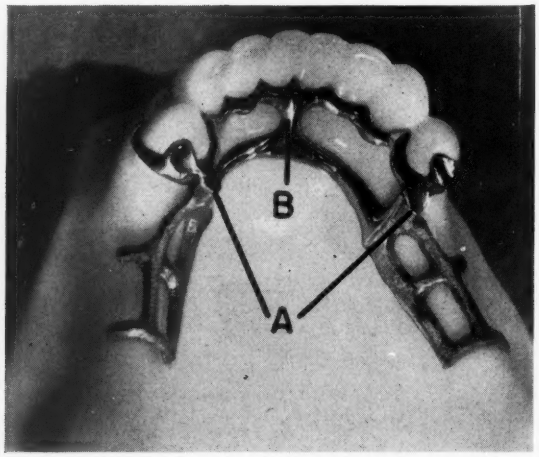

Fig. 5.—Finished casting: *A*, stress-equalizer; *B*, connecting bar.

Fig. 6.—The finished appliance.

attachment freely movable for the predetermined distance which forms a pseudo-precision attachment.

8. Flow a very thin mix of crown and bridge cement around the stress-equalizer over the line-opening left by the dissolved matrix, before the artificial teeth are set up and waxed. The cement protects the stress-equalizer during trial packing and curing, and prevents acrylic from entering the space between the male

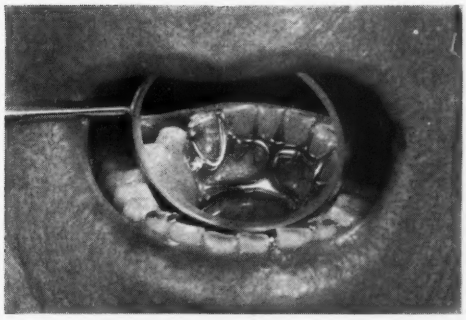

Fig. 7.—The finished appliance inserted.

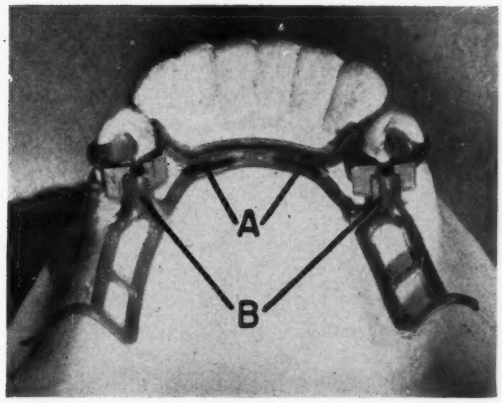

Fig. 8.—Refractory cast waxed: *A*, matrix embedded into the lingual bar to form the split. *B*, matrix in position to form the stress-equalizer.

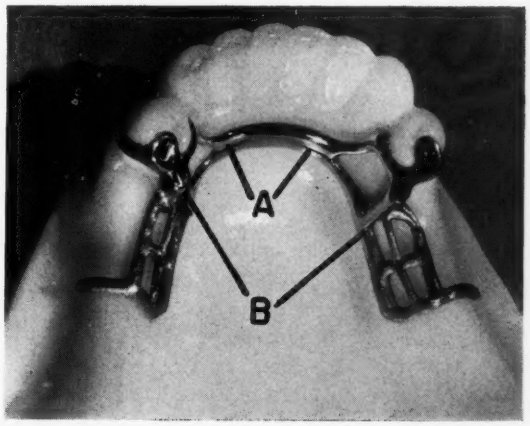

Fig. 9.—Finished casting: *A*, split lingual bar; *B*, stress-equalizer.

and female attachments. After the denture is cured, the cement can be removed easily by chipping during the finishing and polishing process.

We can vary the amount of movement of the stress-equalizer by either increasing the thickness of the matrix or by changing the position of the connecting bar, which is the fulcrum point, either closer to or farther away from the saddle area. If the span of the remaining teeth is from second bicuspid to second bicuspid, two connecting bars are indicated, and they should be placed approximately at the cuspid areas. The cost of materials and time used in construction of the stress-equalizer is insignificant in the construction of a partial denture. No soldering is required, so the original physical and chemical properties of the gold alloy are not destroyed. Lateral movement is held to a minimum, since the female attachment can only move laterally a distance equal to the thickness of the matrix used, thereby maintaining the bracing qualities of the clasps used on the abutment teeth (Figs. 5, 6, and 7).

If a continuous clasp is not desired, it can be omitted, and a split lingual bar used. The split bar is constructed without soldering by embedding the correct length of stainless steel matrix through the waxed lingual bar bilaterally, leaving the midline intact (Fig. 8). The upper portion of the lingual bar is waxed heavy enough so that the gold casting will be rigid. The lower portion which is attached to the upper at the midline is round and finished to a 10 to 14 gauge, depending upon the case. When the finished casting is pickled in the muriatic acid solution, this matrix is dissolved resulting in a split lingual bar, which is necessary in order to place the fulcrum point far enough from the stress-equalizer to allow for the desired movement (Fig. 9). I prefer to use this design wherever possible, because with the round lingual bar, movements of the saddle areas can be better controlled. The appliance is more comfortable to the patient since it is less bulky.

CONCLUSION

The stress-equalizer has been used successfully since 1938. It has been my observation that a very low percentage of dentures so constructed have had to be relined or duplicated. I feel that the reason for this is that movement of the equalizer is limited according to the judgment of the operator. It creates an intermittent, stimulating action on the abutment teeth, their surrounding structures and the edentulous areas. This eliminates trauma and excessive resorption by keeping the occlusal forces applied to each as near to their physiologic tolerance as is possible

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THE REPLACEMENT PROBLEM IN RELATION TO ORTHODONTICS

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THE dentist specializing in the practice of modern orthodontics is very often confronted with patients that, through varying circumstances, are in need of replacements for spaces existing in the denture or in need of closure of spaces where tooth units would normally exist. There are only two methods by which this problem can be met, either open the space for replacement or close the space occasioned by the loss of tooth substance. In the past decade or two, many new techniques and materials have been presented to the dental profession that allow better replacement of artificial tooth units. In all its phases, functional and esthetic restorative dentistry is making great advances. Progress has also been made in the methods of tooth movement so that closure of spaces is more easily accomplished with greater stability than formerly.

In this era of specialization, there is a great need for utmost cooperation between the specialties, if the patient is to be served to the best advantage. It is this cooperation between the orthodontist and the practitioner who is to make the replacement that will simplify the replacement problem as it arises. It may often be that orthodontic treatment will be the determining factor in the successful or unsuccessful crown and bridge or partial denture prosthesis. Orthodontics seeks to accomplish a correct esthetic and functional relationship of the dental mechanism. Uprighting, some possible leveling of an excessive curve of Spee, securing incline plane harmony, proximal contacting depressions, elevations, correction of drifting and restoration of harmony to the arches are tooth movements which are entirely within the realm of orthodontic treatment that are aids in any consideration of crown and bridge or partial denture prosthesis. The patient is deprived of full dental service if the entire occlusal problem is not considered, and if the services of the orthodontist are not fully utilized. There is not one among us who can aid in the advancement of the profession if he neglects to utilize the services of the other specialties.

One of the functions of dentistry is to accomplish artificial replacement of lost teeth. Both from the functional and esthetic standpoint, it is desirable to consider the replacement. It is this consideration of the functional and esthetic phases of dental restorations that has led to the high plane of American crown and bridge and partial denture prosthesis as it exists today.

In the broad ideal, normal occlusion implies that the teeth in the maxillary denture occlude with teeth of the mandibular denture in such a manner that the

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greatest area of functional occluding surface is attained. When a tooth or teeth are missing, the services of an orthodontist can often be utilized, prior to replacing the tooth or teeth, so a better occlusion can be attained. Axial inclinations and rotations are prime examples that, when corrected, change a problem in crown and bridge or partial denture replacement for one that is difficult to one which is much more simple. The "open bite" and "closed bite" are other examples of conditions in which orthodontic assistance can do much to improve the occlusion and make the problem of replacement less hazardous.

ADULT ORTHODONTIA

Orthodontics is not limited to the treatment of adolescents as many dentists think, but can often be utilized in the treatment of the adults. It is my conviction that many adult patients can be benefited by orthodontic treatment, if the laity and the general practitioner could understand the possibility of this service.

There are advantages and disadvantages in the opening of a space for the eventual replacement of a tooth. The mutilation of tooth substance in the adjacent teeth for the construction of a crown and bridge or precision partial denture prosthesis, the periodic changing of the tooth and adjacent structures as age progresses, the inconvenience of wearing a prosthesis for a one-tooth replacement are all factors to be considered as disadvantages in the replacement by crown and bridge or partial denture prosthesis. The contraindications for the permanent replacement of teeth in children, such as large pulps, incomplete calcification of roots, and incomplete growth and development, also can be classed as disadvantages. The latter can be somewhat offset by the procedure of making a temporary replacement in the form of a facing and backing on a lingual arch appliance, or by placing a facing and backing on a "bite plate" or Hawley type retainer.

Humphrey,[1] in a comment on "Results in Attempting to Meet the Problems Presented in Cases Where Some Teeth Are Absent" said, "Retaining spaces so that the missing teeth may be supplied by bridges is often the easier method of treatment and the temporary result may appear satisfactory. Our experience has taught us that we should consider the length of life and usefulness of teeth supporting bridgework because of many likely causes of failures, such as abnormal and increased stress in abutments, and danger to the vitality of the pulp."

There are two major reasons for replacing teeth: first, to restore the normal appearance, and second, to restore the functional usefulness of the tooth in the arch. The greater advantage appears to lie in the esthetic result that is effected in properly constructed crown and bridge prosthesis. The only alternative lies in closing the space left by the missing tooth. This means moving the next tooth in the arch on the same side into the space left by the missing tooth. All the teeth on that side are moved mesially to compensate. In this procedure, the space is eliminated entirely, and all teeth are natural teeth. This is one distinct advantage. Thom[2] said, "The object of a fixed partial denture should be the creation of a healthy mouth with functional occlusion." This same objective is attainable by the space closure technique. This procedure can be completed, and other problems such as changing shades of teeth, and alveolar bone and mucous membrane recession

are eliminated. Functionally, too, the advantages of the space closure procedure weigh heavily in its favor. McCoy[3] stated, "This plan is preferable whenever it is possible to establish an occlusion reasonably fulfilling the requirements of function (without unduly sacrificing esthetic consideration), by closing spaces occasioned by the absence of teeth, through the movement of such other teeth as may be necessary to compensate for the lost tooth substance."

ADVANTAGES OF SPACE CLOSURE

Orthodontic appliances being what they are today, with fixed bands, various auxiliaries, and accurate control of archwire force, it would seem that closure of space is one of the great advantages that can be attained by orthodontic treatment. Space closure is possibly to be favored, but among the criteria are the relative size and form of the tooth lost, and the size and form of the adjacent teeth that will be in proximal contact when the space is closed. Vertical and horizontal overlap, inequality of the size of the tooth structure of the maxillary tooth units to the mandibular tooth units that individually or collectively may be keeping the spaces open, and the labiolingual thickness of individual teeth are all factors to be analyzed if the space closure is to be considered a success from the standpoint of esthetics and stability.

DISADVANTAGES OF SPACE CLOSURE

The divergence from the common concept of normal occlusion, with its fixed pattern of inclined plane relationship, and the so-called "shaking up" of the occlusion unilaterally is undesirable. The possibilities of traumatic occlusion caused by possible malrelation of the cusps of the maxillary teeth occluding with the mandibular teeth must be considered. Also, the esthetic disharmony to the eyes of dentists weighs against this procedure, although this disharmony is either minor or imperceptible to the average layman.

I have closed spaces and I have opened spaces, and have found that when the conditions were favorable, the space-closing procedure has greater advantages than space opening.

Where the central incisor has been lost, and the space has been closed, the preparation of the lateral incisor for a central incisor porcelain jacket crown works out very satisfactorily. The central incisor shaped crown blends easily with the cuspid after a slight modification of the incisal edge of the cuspid by grinding.

CONGENITALLY MISSING TEETH

Congenitally missing and supernumerary teeth often present a mutual problem to the dentist who is considering crown and bridge prosthesis, and to the orthodontist. These cases call for all the skill and cooperation that can be mustered in order to accomplish a stable, esthetic, functional, and healthy tissue result. The problem of two congenitally absent lateral incisors in the maxillary denture is often difficult to make a decision on, but if the spaces can be closed, I believe it is a good procedure to follow.

When a mandibular central or lateral incisor is congenitally absent (a single tooth, i.e., central or lateral), it has been found to be more satisfactory when the space is closed, and no replacement is involved. This procedure may require a slight rotation of some of the maxillary teeth, but patients are better satisfied than they are with the prospect of a bridge or some form of prosthesis for the remainder of their days.

The absence of two mandibular incisors can be coped with best sometimes by space closure, and sometimes by artificial replacement. The requirements applicable to space closure procedures apply to this situation, and judgment must be exercised. When more than two mandibular incisors are missing, some type of fixed or removable prosthesis carrying the replacements is indicated. Skill in the art of crown and bridge and partial denture prosthesis is so necessary in dealing with these cases of congenitally absent tooth units.

Occasionally, a patient will have a congenital absence of two bicuspids in the same area of the mouth. While I have seen a molar placed against the cuspid in this situation, it has always been my experience that a replacement has been necessary to accomplish a good esthetic and stable result.

There are patients in which a number of teeth are congenitally absent. These fall automatically into the category where replacement is necessary. Where four or more teeth are absent, the natural teeth are moved into positions of greatest advantage from the standpoint of esthetics, function, and stability. After a reasonable period of retention, the necessary replacements are made by means of a fixed or removable appliance.

The missing tooth problem is encountered in the child who presents with a permanent maxillary central or lateral incisor knocked out by traumatic impact. Ordinarily, this is a relatively simple problem in replacement. It is temporarily accomplished by placing a facing and backing on a lingual appliance, or by placing an acrylic tooth or facing and backing on a bite plate, but there are many cases in which orthodontic treatment must be undertaken before an adequate crown and bridge or partial denture prosthesis can be placed as a permanent replacement. It is advisable to maintain the space by a removable replacement until such time as a fixed bridge can be inserted. Age, sex, and the psychology of the child regarding interests in play affect the decision as to what period in the life of the individual that a permanent replacement should be made. Most practitioners agree that 15 to 18 years seem to be the optimum age for making a permanent replacement. The chronological age does not always conform with the physiologic development, therefore, mention of an age period for permanent replacement is a mere generality.

A diagnosis of the alveolus must be made before an attempt is made to move teeth forward to close a space in the adult denture. In cases of molar loss with consequent extensive loss of alveolar bone, it is often impossible to position the second molar forward in such a manner that it will have any alveolar bone around it, or the movement itself may be physically impossible. This situation can be best coped with by a replacement, preferably of the precision type.

TIPPED TEETH

In the mutilated cases, if there is no restoration, we can expect tipped teeth, alveolar and gingival destruction and, possibly loss of adjacent teeth. Often the necessary extractions in molar or bicuspid areas lead very quickly to drifting or tipping of molar or bicuspid teeth. The same is true if teeth are missing. These are the patients for whom replacement should be instituted at an early opportunity, if some later orthodontic treatment is to be avoided. Many of these patients can not be treated by crown and bridge procedures unless some orthodontic treatment is instituted. Replacements made in badly tipped teeth frequently lead to the eventual loss of the teeth and an unsuccessful result. Hollenback[5] states, "When abutments are tipped and in poor axial alignment there is considerable danger in the preparation of these abutments in regard to pulp exposure. Abutments in good axial alignment under good conditions must be conservatively prepared, if the pulp is to remain in a normal state of health.

"Proper axial alignment means much to both types of removable bridges in general use today; namely, the clasps of different forms and the precision attachments."

Lasting comfort and satisfaction to the patient can, at times, be attained only if these tipped teeth are uprighted to conform to correct axial stress before any replacement is made. Many of these mutilated cases are being left untreated because of the belief that adult orthodontia cannot be successfully accomplished. These cases can be aided by the combined efforts of the orthodontist and the dentist. This type of treatment will make a better replacement possible for patients with tipped teeth.

Stability or retention is a most important consideration in the orthodontic treatment of mutilated cases. Often the success or failure of the replacement will depend upon the degree of stability attained in the orthodontic treatment. Much attention should be devoted to the attainment of the utmost degree of stability.

EXTRACTION OF CUSPIDS FOR ESTHETICS

Another factor involving the replacement problem is the extraction of cuspids by the dentist with good intentions of aiding his patient from the esthetic standpoint. This has led to mutilation in a great number of these patients, instead of to the much desired improvement. Any extraction of teeth under these circumstances should be undertaken only after the entire mouth has been studied. In this, the orthodontist can often render collateral consultation service which is of value both to the patient and the dentist. All too often when cuspids are extracted, the end result is a space that is only partially closed, due to factors of occlusion that prevent proper space closure. This condition leads to an impossible or awkward replacement when the patient is in the hands of the dentist doing any future crown and bridge or partial denture prosthesis.

ORTHODONTIA AND CLEFT PALATE TREATMENT

The replacement problem for cleft palate patients can be simplified by orthodontics. As a general practical working objective in the treatment of cleft palate

patients, we first endeavor to place the mandibular teeth in the most favorable relation to the mandibular base bone. This may or may not mean the removal of individual tooth units in the mandibular denture, depending upon the individual malocclusion present in this denture. Then when the decision as to the position of the mandibular teeth has been determined, the available maxillary tooth units are positioned in the best possible relationship with the mandibular tooth units. Replacement by either crown and bridge or partial denture prosthesis is finally completed after active orthodontic treatment.

ORTHODONTIC RETENTION AND REPLACEMENT

The replacement problem is definitely related to the retention problem in orthodontic practice. Once the replacement is completed in the finished orthodontic case, the replacement is subject to the same evils that always threaten the completed active treatment case. Habits, muscular influences, third molars, the subsequent loss of other teeth, and the influence of the natural forces in normal growth must be given consideration in the development of retention after orthodontic treatment. It is true that stability is one of the ideals and the aim in orthodontic treatment. It is also not true that this stability is attained in all cases that the orthodontist treats. These failures occur apparently under the most favorable conditions, therefore, it is certainly unwise to expect that there will be no failures in adult cases treated in preparation for a replacement. Adult orthodontia can be successful even though there is an idea prevalent in the minds of many laymen and some dentists that at a certain age the bone becomes so set that it is impossible to change the positions of teeth.

SUMMARY

The replacement problem can be solved by one of two methods: (1) closure of space, and (2) opening of space to allow replacement by an artificial tooth unit or units.

If the space closure is possible, then vertical and horizontal overlap, inequalities of tooth structure, and the labiolingual thickness of teeth are factors to be considered. If the space opening procedure is indicated, the condition of abutment teeth and tissues as to position and quality, plus the relation of the teeth in the opposing jaw are the factors to be considered.

Our patients have every right to expect us to render the utmost of our individual and combined abilities. We must continue to strive to give them the best of our knowledge and ability to which they are entitled.

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AN IMPROVED TEMPORARY ACRYLIC FIXED BRIDGE

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THE purpose of this article is to suggest an improved and simplified method of constructing acrylic bridges and splints prior to the preparation of teeth. The current techniques, as described by Talkov[1], fall short of the ideal. In order to overcome the disadvantages of the techniques already in use, a new technique was devised. It makes possible the construction of a temporary acrylic bridge or splint of eggshell thickness, which is an exact duplicate of the original anatomy or any modification of it. Construction time is a matter of minutes; the bridge or splint is ready for use before the abutment teeth are prepared. Appropriate incisal, body, and gingival shades of acrylic can be used where indicated.

THE TECHNIQUE

An alginate impression is made only of the area to be reconstructed. A small amount of a water soluble dye is added to the alginate as it is mixed. When the impression is to be made from the study cast, edentulous areas can be filled in with acrylic teeth or properly molded wax, and any necessary corrections may be made on the abutment teeth by the addition of wax. In cases where the alginate impression is made in the mouth, similar corrections can be more crudely effected by carving out the alginate in the indicated areas. Naturally, a better result is obtained when the corrections are made on the study cast. Fig. 1 shows the study cast of a proposed anterior bridge and splint involving two missing teeth and five abutment teeth. Fig. 2 shows the replacement of the missing teeth on the cast with acrylic teeth, which can be carried over in the alginate impression and made part of the temporary restoration. The broken down abutment teeth have been built up and restored with wax.

The next step is the construction of a thin shell of acrylic, the outer form of which is the exact shape of the desired temporary bridge or splint.

Rapid or "cold" curing acrylic powder and liquid are placed in separate dappan dishes. The excess moisture is removed from the impression by a blast of air, and the acrylic is painted into the alginate impression with a brush such as is used to invest inlays. The brush is first moistened in the liquid, and then a generous quantity of powder is picked up by the moistened brush. The acrylic is then applied in the impression so a uniform layer will result (Fig. 3). By using a blast of

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warm air after each layer is painted on and by tilting the impression so that gravity will control the flow of the soft acrylic, it is possible to prevent the formation of thick sections. When it is set, the acrylic should be of eggshell thickness. The interproximal areas can be made thicker in order to provide additional strength. The gingival margins can be overextended slightly to assure full gingival coverage. The dye that was added to the alginate impression material will provide greater color contrast between the acrylic and the alginate. Appropriate shades of acrylic can be used in the incisal, body, and gingival areas when necessary.

Fig. 1.

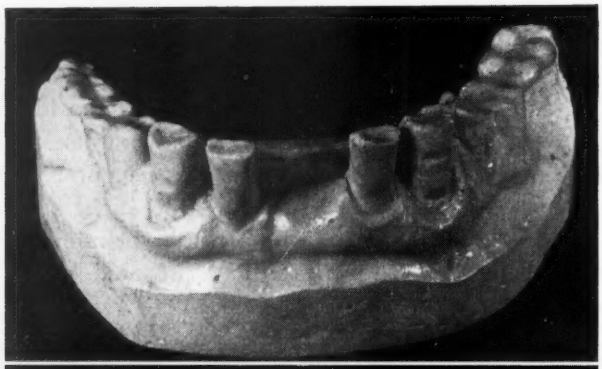

Fig. 2.

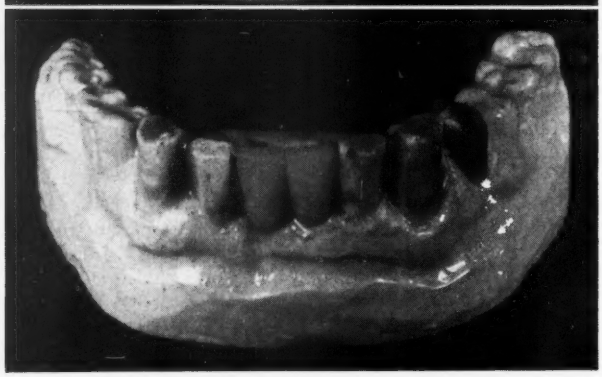

Fig. 1.—Study cast of a proposed anterior bridge and splint involving two missing teeth and five abutment teeth.

Fig. 2.—The missing teeth have been replaced with acrylic teeth, and the abraded abutment teeth have been rebuilt with wax.

When the acrylic has set, it can be removed from the alginate impression by prying it out with an instrument. A small pair of scissors is used to trim away any overextensions. Care is exercised in order to avoid chipping the essential portions of the acrylic crown forms. It is better to leave slight overextensions which can be more easily removed when the bridge is completed. The trimmed acrylic shell of the bridge is shown in Fig. 4. Any areas that have been built up too thickly inside the impression can be reamed out intracoronally.

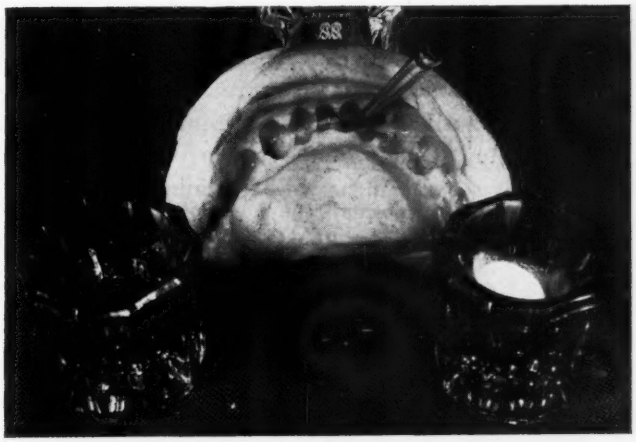

Fig. 3.—Rapid curing acrylic is painted into the alginate impression to form a shell of uniform thickness.

Fig. 4.—The acrylic shell.

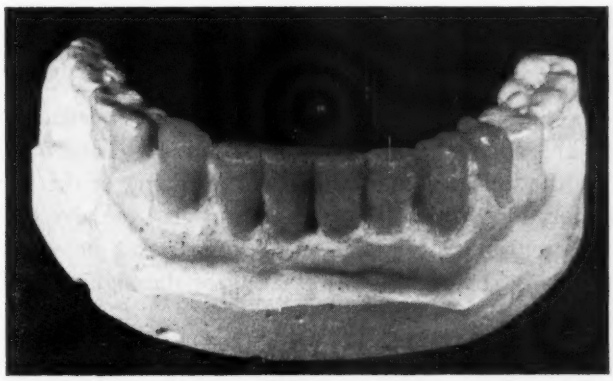

Fig. 5.—The completed bridge on the study cast as it would appear in the mouth.

The acrylic shell is thin enough and flexible enough to fit over any adequate full or jacket crown preparations. After the abutment preparations are completed, the shell is tried into place and adjusted, if necessary. A thin mix of cold acrylic is placed in the shell to fit it to the teeth. The patient is instructed to close against the bridge in order to establish the proper occlusion. The excess flash at the gingival margins of the abutment shells can be removed while it is soft. The bridge is removed or lifted slightly several times while the lining acrylic is setting in order to prevent binding when it is fully set. The patient can rinse the mouth with warm water to hasten the setting of the acrylic. A small amount of finishing and polishing completes the bridge, which is cemented with a temporary cement (Fig. 5).

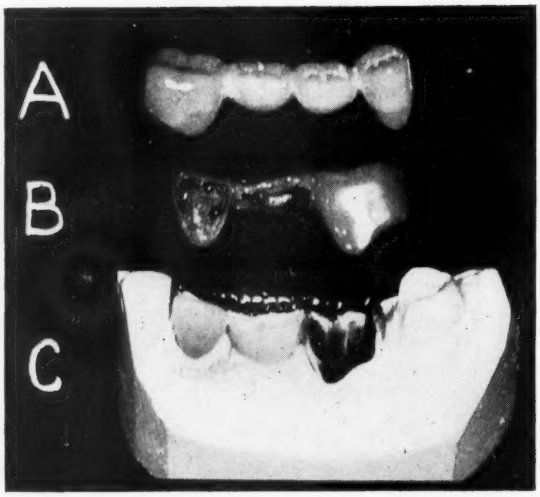

Fig. 6.—*A*, Acrylic bridge with sanitary pontics. *B*, Acrylic bridge with wax retention loops. *C*, Finished bridge made from the pattern shown in *B*.

The advantages of this method of making temporary fixed bridges are: (1) The construction is completed rapidly and in simple fashion. (2) The acrylic shell is completed before the teeth are prepared. (3) It is not necessary to mutilate or destroy the study cast. (4) Surface defects and shrinkage away from the gingival margins are eliminated. (5) Contraction and consequent binding are greatly reduced by the fully set outer shell. The relining of the shell can be done in stages in especially long splints in order to prevent excessive contraction. (6) Adjustment of the occlusion is minimal, as the patient can close the teeth together while the splint is being relined. (7) Reseating of the alginate impression in the mouth is eliminated.

As an experimental procedure, some of these acrylic bridges have been invested and cast in one piece. Fig. 6 shows two different types of permanent bridges that have been constructed in this manner. *A* shows a four unit acrylic lower posterior

bridge with sanitary pontics that was subsequently cast in gold. *B* shows an acrylic bridge with wax retention loops. *C* shows the finished bridge made from *B*. Although this experimental technique of finished bridge construction has interesting possibilities, further research is necessary in order to establish its practicability.

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THE CHECKBITE-IMPRESSION TRAY FOR HYDROCOLLOIDS IN RESTORATIVE DENTISTRY

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THE checkbite-impression tray, in its present three forms, was born of the necessity to find an answer to the question of an accurate checkbite when that problem arose, in the experience of the author, following the adoption of hydrocolloid as the impression medium for his inlay and crown and bridge work. The final form is a design, the purpose of which is to give an accurate checkbite simultaneously with an inlay, crown, or other abutment impression, and it represents some years of trial and modification.

Though it might seem faster, clarity and understanding of the tray and technique are not served by an abrupt description of the instrument and its use. Prior knowledge of the chemical and mechanical details that make its unusual success possible will lead to a better understanding, as will a little review of some phases of the hydrocolloid technique as we know it today.

The use of hydrocolloids in the impression phase of inlay and crown and bridge work has not been accepted as widely as its merits might presuppose. If it is only caution attending the introduction of something new, the profession is fortunate; but if it is intellectual inertia, that lazy reluctance to drop the old for the new because it is at first troublesome, we are not discharging our obligation to the public. There must be a turning point, but in this shift from the old to the new it is perhaps hard to decide exactly where or when that turning point should come; where experimentation stops and practice begins.

It is becoming increasingly apparent that the phase of experimentation with hydrocolloids in inlay and crown and bridge work has been passed quite some time ago, except for refinements. Disadvantages to the use of the reversible hydrocolloids are few and minor. These must be classified mostly as the present, but probably not permanent, deficiencies of all the other materials used in the various phases of the full technique, from the impression to the finished work. The accuracy and dependability of the hydrocolloids is quite well established; that of the alginates is in serious doubt. A truly durable die material is still wanting for use with the whole class of hydrocolloids, so the search continues for a harder material or a proved method for electroforming dies. The newer die stones give consistent and accurate results with proper handling. A little change in laboratory procedure for finishing is required with them. This necessitates a little more caution in the handling of the

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wax pattern and the margins of the gold restoration. A competent technician can master the use of the stone die quite as easily as any other procedure requiring an eye for detail. A successful method for copper plating hydrocolloids might answer the die problem more fully in this newest and most promising technique.

Investments, waxes, and gold alloys remain much the same, and probably only minor refinements are possible, or even necessary, now that some of the remaining troubles have been eliminated mostly from the laboratory end of the work by the introduction of vacuum investing and thermal controls of investing, wax elimination and casting.

The picture today promises an almost universal use of the hydrocolloids for the making of individual or multiple inlay, crown, or other abutment impressions, leaving only refinements in the technique and further accuracy of all the materials involved to be worked out. While it was once felt by some that one day the alginates might be made to perform like the reversible hydrocolloids, thus eliminating the more cumbersome technique involving conditioning units, syringes, and tray-cooling systems, the idea has been abandoned by the author and many of the others. Experience has shown that the same consistent results cannot be expected from the alginates as from the reversible hydrocolloids. Elaborate dodges were devised to try to raise the over-all performance of the alginates, only to find that there are apparently one or two inherent properties that cannot be overcome. As an example of these efforts, a divided-portion routine was worked out. The first portion of alginate for use around the preparations was mixed somewhat colder than the second or main mass of the material. It was felt that controlling the temperature, and thus the set of alginate, was the answer.

In practical cases for experimental reasons, I have made the impression I wanted with the two materials, and produced dies on which the inlays were interchangeable three ways; each inlay fitted both dies and the tooth which they represented with equal accuracy. Unfortunately, this cannot be done every time because all of the variables entering into the behavior-determining pattern of the alginates are not fully understood, and cannot be fully controlled until they are understood. In contrast, I have had practically no failures, under any circumstances, with the reversible hydrocolloids.

After many disheartening experiences in making inlays, crowns and bridges, it was decided that the ultimate in possible accuracy had not yet been obtained with the elastic impression materials. The impressions of the preparations were accurate, but the occlusion was high, and the contact points were faulty. It was seen that these and other deficiencies were due to the common technique of using an inaccurate wax checkbite in conjunction with hydrocolloid-accurate dies and casts. Even the making of full arch casts did not solve the problem. Too often they had to be articulated with a wax checkbite or by eye, both inaccurate methods. The full arch impressions and casts also seemed unnecessary where only a restoration or two was involved, as is often the case in an average general practice.

THE CHECKBITE TRAY

It soon became quite apparent that a checkbite must be made which would be as accurate as a hydrocolloid material would allow. In other words, it became de-

sirable to obtain the checkbite in hydrocolloid; this would give the desired accuracy, and at the same time save the patient time, discomfort, and annoyance while it saved the operator time and annoyance. To meet this requirement, the checkbite-impression tray was developed. It is a sort of rigid bite former with perforated walls which are held rigidly in one unit by a connecting bar that passes distal to the last tooth in the arch. Extending connections for attaching rubber hoses for circulating cool water form a handle. A slot provides a means of retaining a piece of fibrous paper at the plane of occlusion. Miracloth is readily available, and is ideal for this purpose because of its strength when wet, and because the fibers retain the impression material. This prevents any peeling or separation of the impression material from the paper.

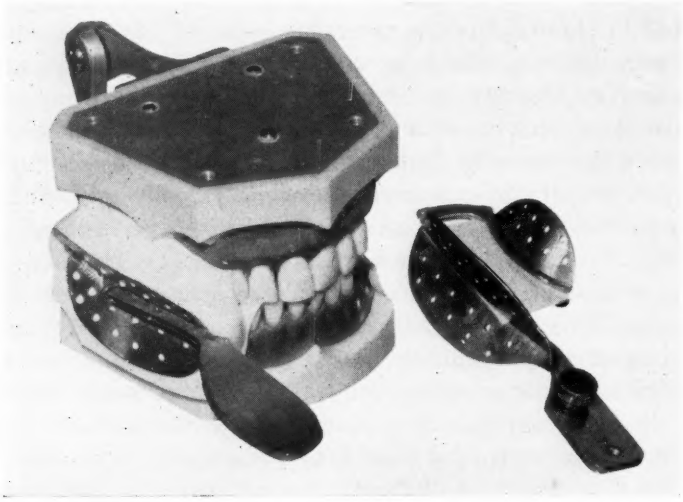

Fig. 1.—A unilateral checkbite-impression tray, without cooling tubes, showing the Miracloth paper in place, and a similar tray in place on a typodont "case" showing the making of a checkbite-impression. (Courtesy New York State Dental Journal).

This tray design makes possible a simple checkbite in alginate or in reversible hydrocolloid. The interocclusal record for the molar and/or premolar areas on one side is made at the same time that the inlay, crown, or other abutment impressions are made (Fig. 1). Thus, in one operation, one simple step, an impression of both the preparations and the opposing teeth in correct relationship is obtained (Fig. 2). The remainder of the technique for making of the individual dies, and pouring of the two sides of the checkbite is the same standard routine as formerly. Now, however, the inlays, crowns, or bridges can be finished on the articulator with an assurance that no adjustments, or only very minor finishing ones, will be necessary in the mouth.

A note of caution should be introduced here in reference to the actual making of the impression, as it is the most important consideration involved, and the point of most objection for those who hesitate to try the hydrocolloid technique. The

gum tissue must be sufficiently free from the tooth so that the hydrocolloid mass will flow over all tooth surfaces freely. Hydrocolloid will not push back tissue or moisture to record the preparation. The method used for controlling the tissue and exposing all details of the preparation must not be destructive to any tissue it is desirable to keep. Undesirable or unimportant tissue can be removed chemically or mechanically, but desirable tissue must be put aside temporarily and with the least possible harm. This may be done mechanically by packing the gingival crevice with gutta percha, cotton pellets or ropes, cotton string or thread, aluminum crowns, or other devices to expose a margin. The gingival tissue can be retracted chemically by using astringents in conjunction with the various cotton packings. A 40 per cent solution of zinc chloride is effective and not harmful if it is used judiciously. In stronger concentrations, zinc chloride is a dangerous caustic. Seepage from irritated tissue can be controlled with vasoconstrictors, such as adrenalin, or by the spot application of styptic drugs.

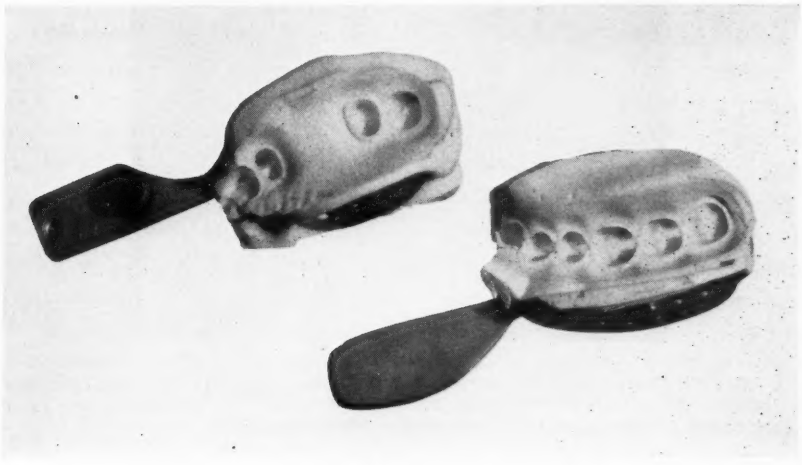

Fig. 2.—The checkbite-impression, demonstrated with two similar trays, to show the upper and lower impressions that would be obtained simultaneously with one checkbite-impression in one tray. (Courtesy New York State Dental Journal).

Another note of caution concerns the space between the gingival floor of the preparation and the adjacent tooth. If it is too narrow, the hydrocolloid will tear. A modification in the usual preparation has been found useful in eliminating this problem as well as providing for better restorations. The preparation of the tooth is also made easier by the modification. If the proximal slice does not include the gingival margin of the area to be restored (due to the beginning of the root concavity), or if the bevel of the gingival aspect of the box is too narrow, a long bevel is made in this gingival area with a tapered diamond point. The preparation becomes, in effect, a modified concave slice, the margins of which pass uninterruptedly into the margins of the box or slice, whichever is used. The preparation must be just as free from undercuts as one which is to be recorded in modeling com-

pound. If undercuts exist in the preparation, the impression can be removed, but the die will show the same undercuts which will cause difficulty in making the wax pattern.

By the hydrocolloid method of making impressions it is possible to make large restorations that would not be handled adequately by a direct pattern technique, or by an indirect compound-tube impression technique. Hydrocolloid will reproduce any exposed surface accurately; any modified or unique preparation that meets the requirements of the tooth can be used.

Fig. 3.—The checkbite-impression tray in place in the mouth. Water is circulating to cool the hydrocolloid. All cavity preparations, adjacent teeth and all opposing teeth on this side are being recorded simultaneously in the correct relationship.

THE TECHNIQUE

The assistant fills the tray with reversible hydrocolloid on the side of the paper which will be opposite the restoration. This material will record the surfaces of the teeth against which the restoration will occlude. The tray, with one side filled, is placed in the tempering bath to reduce the flow of the hydrocolloid. This makes the impression material easier to control when the reverse side of the tray is filled, just prior to the actual taking of the checkbite-impression. While this is being done, the operator dries the prepared tooth or teeth. The assistant then hands the operator a small syringe filled with hydrocolloid, and removes the tray from the tempering bath, and fills the second side of the tray, which will make the impression of the preparations. While the assistant is filling the second half of the tray, the operator injects hydrocolloid around and into the preparations by means of the small syringe. Next, the operator receives the completely filled tray from the assistant as she relieves him of the small syringe. He

places the tray in position and directs the patient to "close" (Fig. 3). Then cool water is circulated through the tray. The cooling is continued for about four minutes, or until the mass is thoroughly chilled and gelled. I attach one tray hose to the saliva ejector line, and place the other hose into a glass of water which is placed in the unit where the patient's rinse glass is customarily kept. Water from the unit is run into this glass so that as water is drawn from the glass through the tray and out the saliva ejector, it is constantly replaced. This suction arrangement for cooling eliminates the possibility of messy accidents due to leaks in the hose connections under pressure, or due to spilling water from a pan on the bracket table. When the checkbite-impression is thoroughly chilled, the patient is instructed to "open with a snap." This will prevent dragging or tearing of the hydrocolloid impressions. Hydrocolloids are distorted less by a sudden displacement than by a dragging or rocking motion.

DIE POURING

The completed checkbite-impression is immediately placed in a 2 per cent potassium-aluminum sulfate solution. The solution is freshly prepared with tap water at the same temperature as that used for cooling the hydrocolloid in the mouth. This temperature control prevents a volume change in the hydrocolloid mass until the dies are poured, and set. The exact temperature of the water is not important. If the tap water is 65°F., the cooling and the fixing will be at 65°F. In the summer, the water temperature might be higher, but ice will not be required. This is the simplest, easiest, fool-proof control of temperature that can be devised. While the check-bite impression is immersed in the fixing bath, some die stone is mixed with tap temperature water, thus the temperature control is maintained. Approximately two minutes are required to prepare for pouring the dies. This allows sufficient time of immersion for the treatment of the surface of the hydrocolloid impression. The checkbite-impression is removed from the solution and the excess solution is blown out. The dies are poured with good bases, dowels are inserted. The impression is placed on the bench until the stone just begins to set, or until the sheen is off the surface of the stone. It is then placed in a humidor for the stone to complete its set. All this is done while the assistant gets the bracket table cleared and ready with the materials and instruments for the protection of the prepared teeth. Once the dies have set, the details of the critical areas of the checkbite-impression have been recorded, and the remainder of the casts and articulation can be completed hours or even a day later. The articulation is completed by painting a separating medium on the dowels and on the bases of the dies before stone is poured around them in the impressions. The dies are not disturbed in any way until all the stone in the entire articulation has set. Then the dies are separated with a jeweler's saw at their mesial and distal aspect by cutting down to the line of separation which forms the base where the dowels protrude. The dies are removed and trimmed so there is access beyond all margins of the preparation for the waxing and carving of the patterns (Figs. 4 and 5).

This method avoids the danger of introducing inaccuracy by improper reseating of the dies. It has been found to be unnecessary to treat the dies with oil

because the supposed benefit of toughening the die is questionable, or at least the slight toughening that might occur is of questionable benefit. It is even possible that soaking the dies in oil obliterates some of the fine detail. The use of a separating medium like Microfilm is preferred, and is most satisfactory.

Fig. 4.—The articulated "case" disassembled to demonstrate the removable, dowled dies. (Courtesy New York State Dental Journal).

Fig. 5.—One piece, cast bridge made from the checkbite-impression articulation shown in Fig. 4.

When the dies have been completed and the two casts have been poured, the occlusal surfaces of the opposing arches of teeth are related with great accuracy. The use of the checkbite-impression tray allows for a great saving in time and effort, and reduces much of the discomfort and tediousness associated with methods which require the use of separate impressions and wax checkbites.

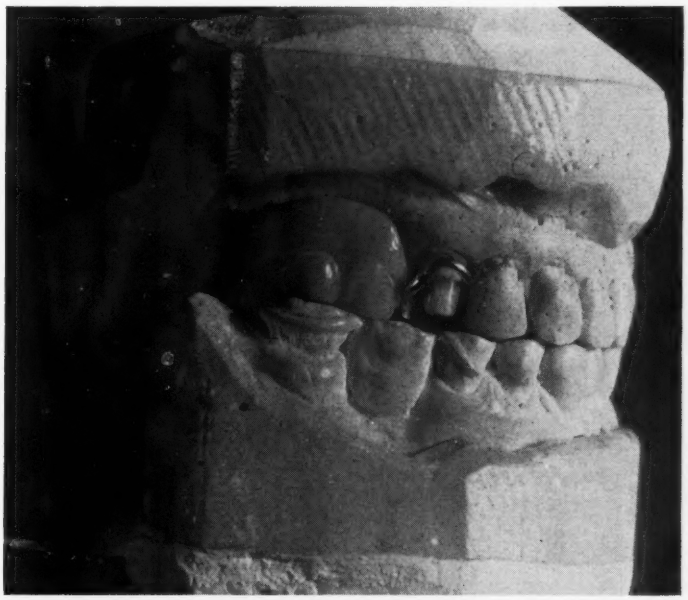

Fig. 6.—A checkbite-impression mounting for the repair of a broken abutment tooth which has been prepared for a veneer crown under the clasp and rest of the existing removable prosthesis.

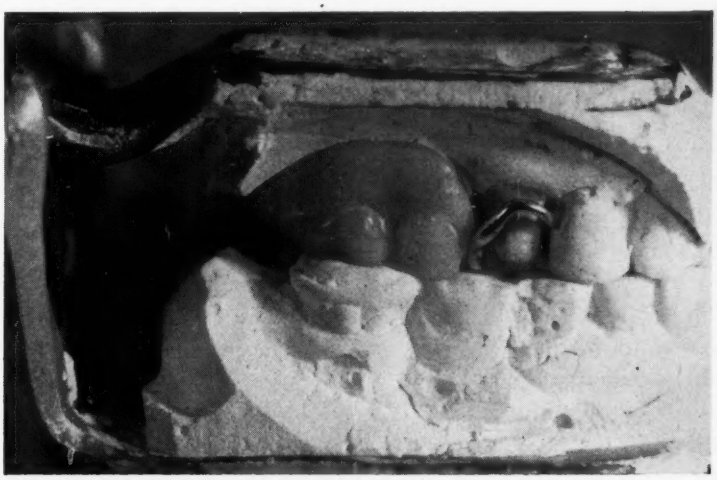

Fig. 7.—The articulation made from a checkbite-impression of mounting in Fig. 6.

The unilateral tray has been put to many practical uses. Various types of repairs and additions have been made easier with the single checkbite-impression. The restoration of a broken abutment of a partial denture by a crown or inlay under the clasp and rest can be made easily and with accuracy (Figs. 6 and 7). Bridge components may be articulated exceptionally well when the checkbite-impression tray is used. For this purpose, a *stiff* alginate impression material is ideal. The components of the bridge can be reseated surely and firmly in the impression for the placing of the dies. Low fusing metal is poured into the impression to complete the cast. This procedure is used where it is advisable to make separate components from a checkbite-impression or from separate impressions of the abutments which are to fitted in the mouth before completing the bridge.

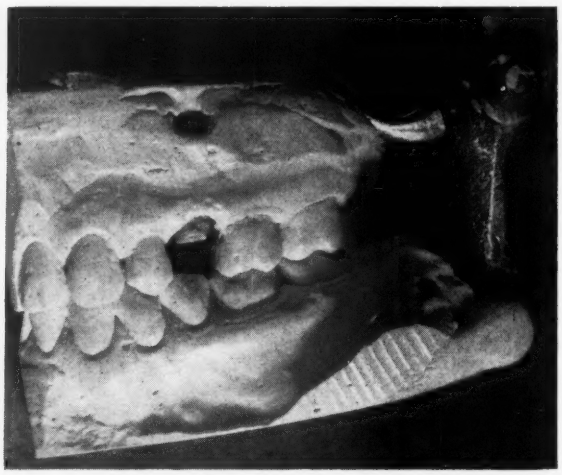

Fig. 8.—An articulation produced from a checkbite-impression made with the unilateral tray using alginate. The die was produced separately from a copper band-and-compound impression, and incorporated in the articulation.

If the tray was never used for anything except for making checkbites, the technique would assure better end-results for any method of inlay or abutment impression making. For this purpose, a stiff alginate is preferred. Previously made dies can be articulated in the alginate checkbite-impression, which then takes the place of a wax checkbite. This procedure is used when a tooth, broken at or near the gingival margin, is to be restored with a crown anchored by a gingival band and a pin in the root canal (Fig. 8). The gold pin is fitted into the canal of the root with its prepared stump, and a compound-copper band impression is made with the pin in place. The die is then made, into which the pin is automatically transferred from the impression into the die. A cap is waxed to the pin in such a way as to include the bevel of the stump and so to band it. This is cast in gold to form a cap with a small flat-sided stump and a pin. The casting with the pin is now fitted to the prepared stump in the mouth, and a checkbite-impression is made with a stiff alginate impression. The cap and pin remain in the mouth due to their tight fit, but because of the characteristic impression left in the alginate by the flat-sided

stump on the coronal aspect of the cap, they can be placed on the die and accurately seated in the impression. The casts are poured and mounted on the articulator for the completion of the crown. When the casts are thus articulated the amalgam or copper die is in a perfect relationship to the adjacent teeth and to the opposing teeth. The well-fitted cap and pin are ready for completion of a crown. Procedures which use plaster and wax will not give the same accuracy, and are considerably more time consuming and troublesome.

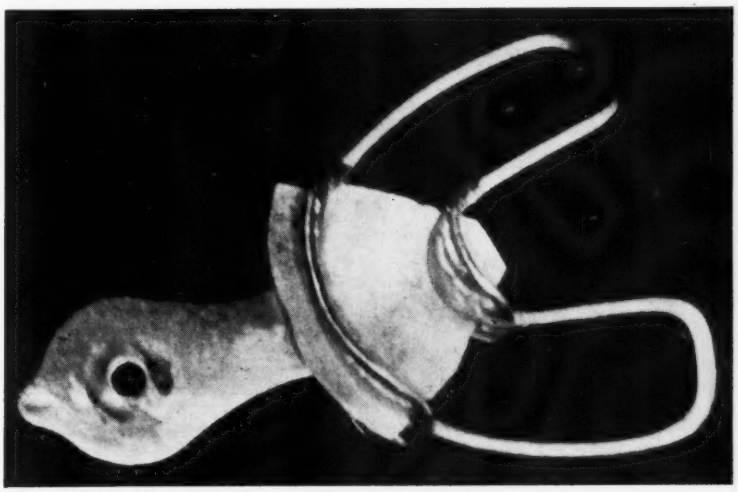

Fig. 9.—The anterior checkbite-impression tray with the paper insert in place. The finished design of this tray is water cooled.

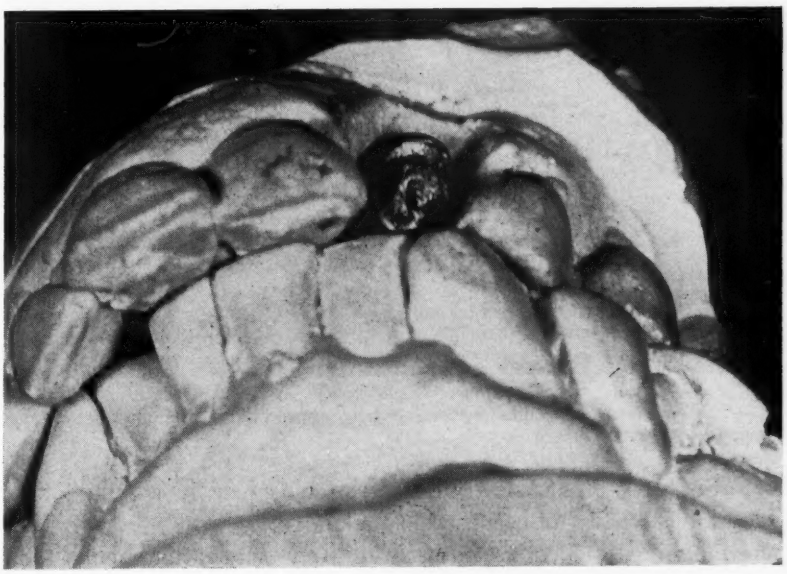

Fig. 10.—An articulation made from an alginate checkbite-impression with an anterior tray. Note the separately made die and the lack of distortion which is not possible with wax.

The anterior checkbite-impression tray utilizes the same principle as the unilateral tray but includes only the anterior segment of the dental arch (Fig. 9). It is used in anterior jacket and bridge work to produce a checkbite that is minutely accurate in every respect. The impression for a jacket may be made by the usual tube method with compound or wax. This is followed by an alginate checkbite-

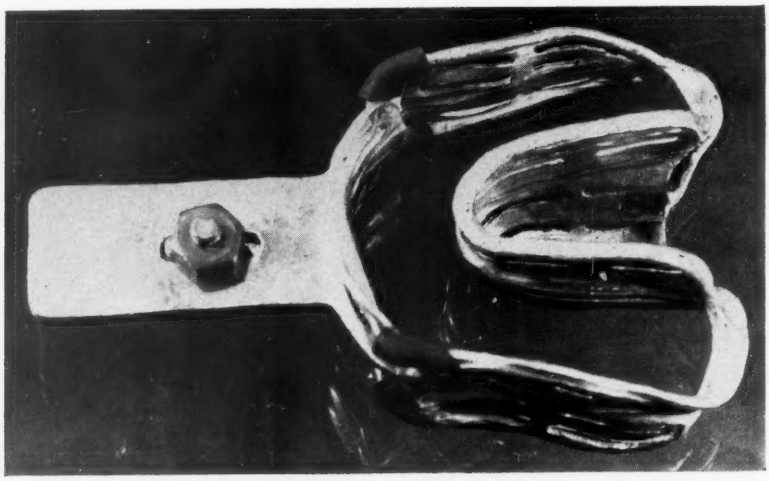

Fig. 11.—The full arch checkbite-impression tray viewed from the mandibular aspect. Paper inserts are not in place.

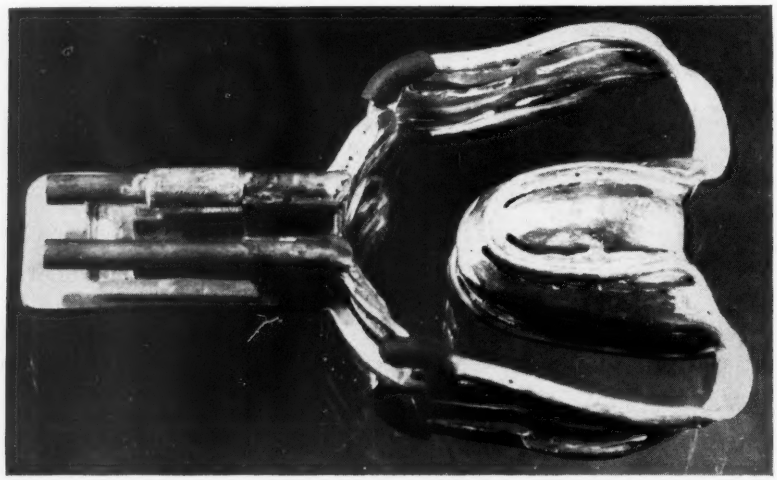

Fig. 12.—The full arch checkbite-impression tray viewed from the maxillary aspect. Note slots for paper inserts.

impression (Fig. 10). The checkbite-impression is held in a humidor while the die is made to avoid a loss of accuracy in the alginate.

Where individual jackets are to be made over banded abutments, the transfer of bridge framework and pontics after fitting is done easily and precisely with the anterior tray and a stiff alginate.

Where an anterior bridge with inlays or pinlays are used for attachments, the complete checkbite and abutment impressions are made with reversible hydrocolloid. The anterior tray will record detail as far distally as the premolar areas.

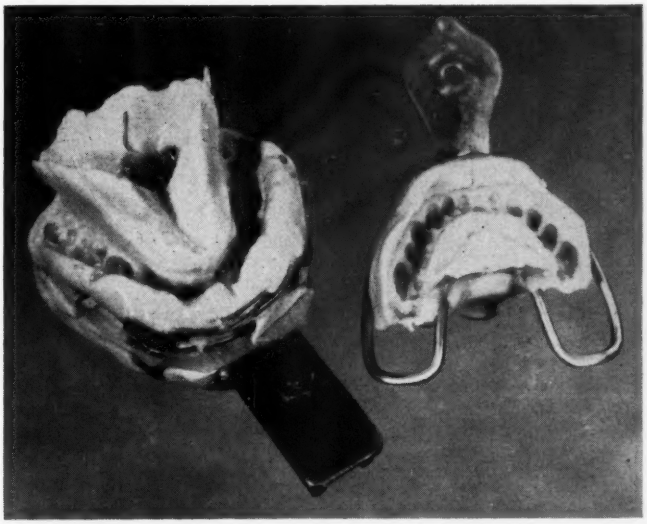

Fig. 13.—Two completed anterior and full arch checkbite-impressions as seen from the mandibular aspect. Note the detail of the interior anatomy of the mouth.

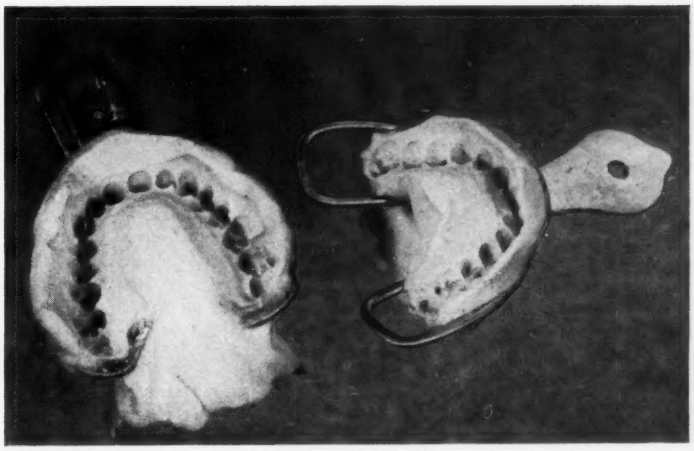

Fig. 14.—Two completed anterior and full arch checkbite-impressions as seen from the maxillary aspect. Note the detail.

The full arch checkbite-impression tray perhaps holds the greatest promise of all, though it will definitely not replace the other checkbite-impression trays in practice. The full arch tray is designed to record, in one step, the upper and lower arches in their occluding relationship, and all abutment preparations or edentulous areas to be restored (Figs. 11, 12, 13, and 14). It makes possible an upper and

lower impression that is as good as, and sometimes better than can be made in individual upper and lower trays (Fig. 15). This is probably so because the mouth is closed in centric occlusion and all muscles are more or less relaxed. It provides a good registration of the mucobuccal fold, muscle attachments, and an excellent record of the throat form. But most important, the checkbite relationship is absolutely correct. The same accuracy cannot possibly be achieved, in many cases,

Fig. 15.—Two simple articulations made from checkbite-impressions made in the full arch tray.

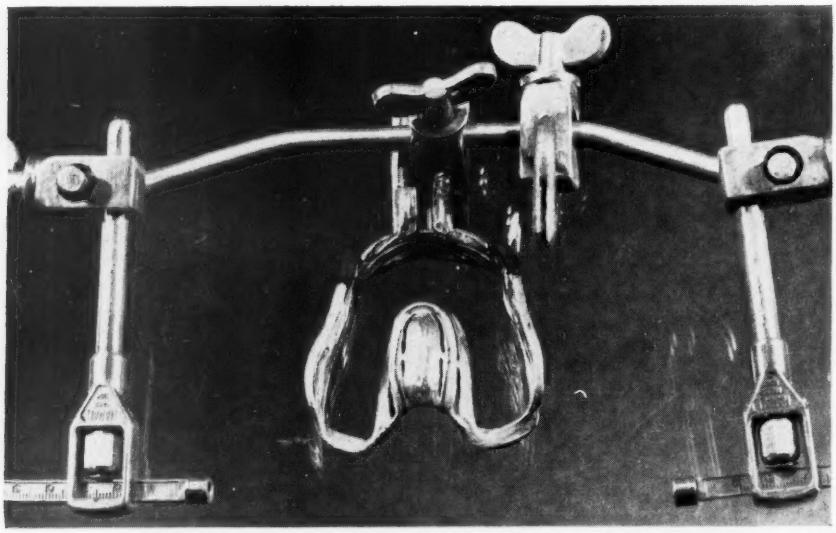

Fig. 16.—The full arch checkbite-impression tray with a simple face-bow mounted to the handle. The paper inserts are not in place.

by making individual impressions and wax checkbites for articulating the separate casts. Casts cannot be articulated correctly by hand-and-eye methods. This making of an impression of the interior of the mouth with the teeth occluding is truly making an impression of the checkbite relationship. This gives true meaning to the descriptive phrase chosen for the new tray and concept.

The checkbite tray opens up countless possibilities, and many uses suggest themselves. It has been possible to reproduce on an articulator a record of pre-

mature occlusal contacts in about twenty minutes (Figs. 16, 17, 18, 19, 20, 21, and 22). Ordinarily it would take about three to five hours to produce the same records with separate impressions, a wax checkbite, a face-bow registration, and split cast mounting on the articulator.

Fig. 17.—The checkbite-impression has been made. After the impression material has set or gelled, the face-bow is mounted and adjusted as shown.

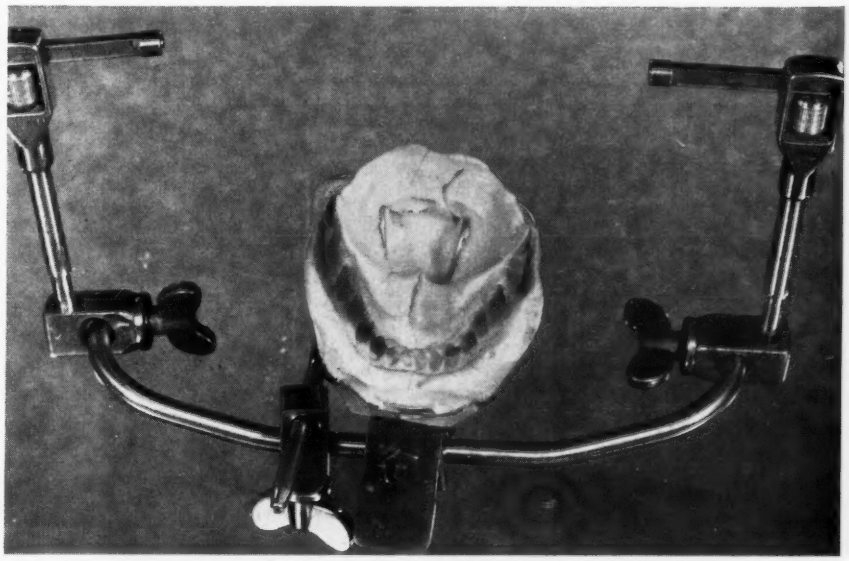

Fig. 18.—Mandibular aspect of full arch checkbite-impression after removal from the mouth with the face-bow locked for transfer to an articulator.

The orthodontist can quickly get registrations that are now difficult to obtain with certainty. The periodontist can get checkbites of real significance for the study of traumatic occlusion and its correction by equilibration. The specialist in mouth rehabilitation, regardless of his school of approach, can find a place for the checkbite tray in studying occlusal relationships in recording eccentric occlusal relations

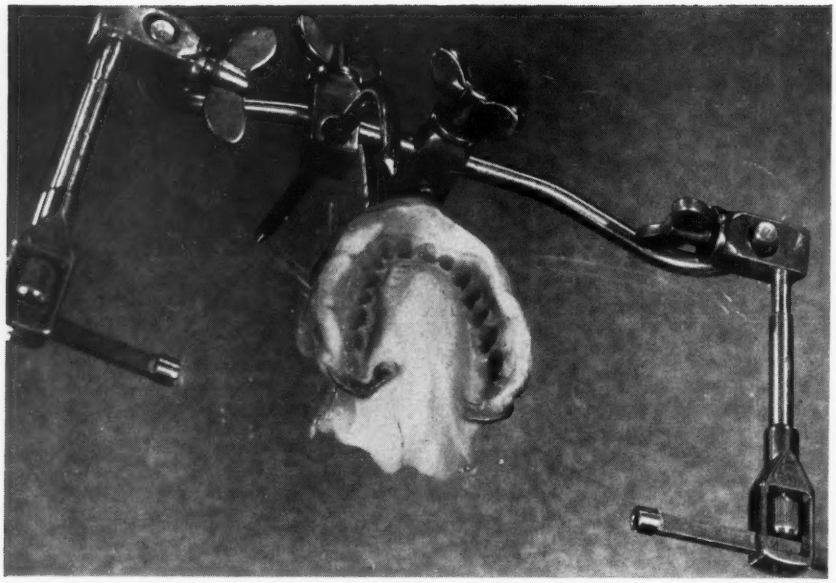

Fig. 19.—Maxillary aspect of the checkbite-impression in Fig. 18.

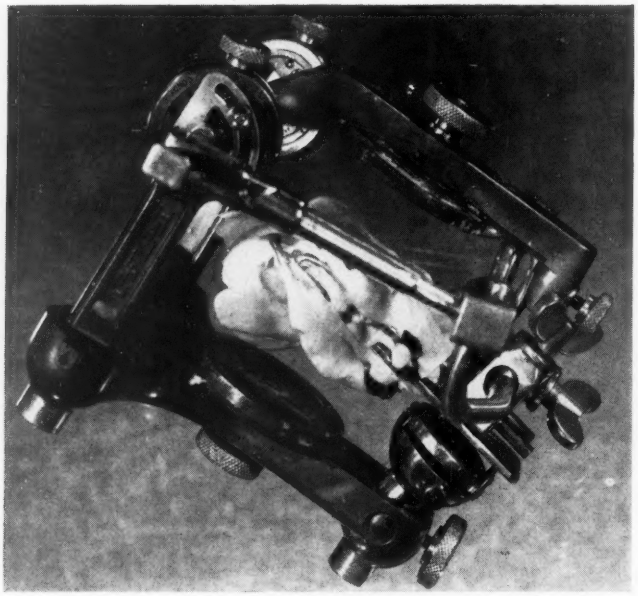

Fig. 20.—Side view of face-bow adjusted to articulator and ready for the combined pouring and articulation of the checkbite-impression.

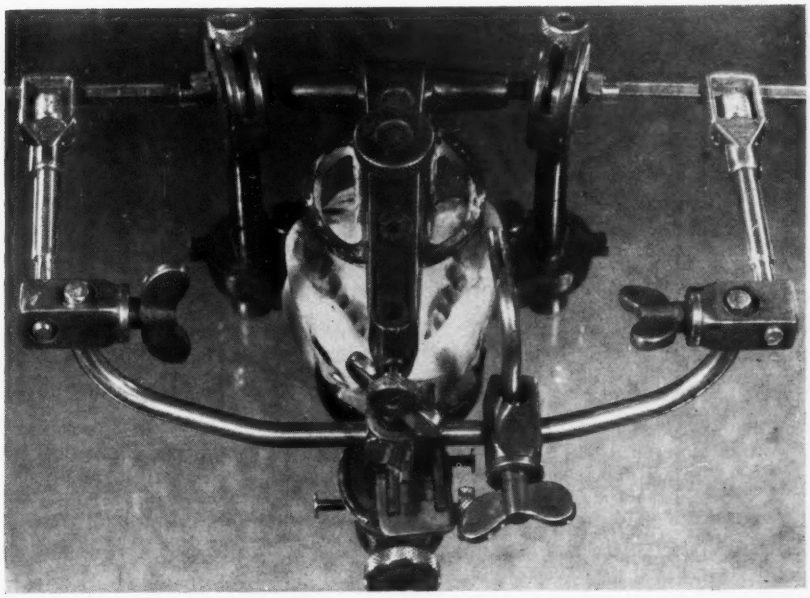

Fig. 21.—Top view of the same step as shown in Fig. 20.

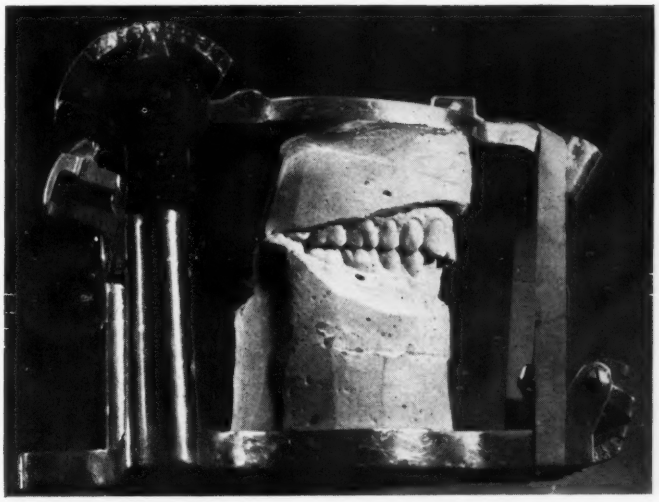

Fig. 22.—The completed mounting of casts made from a checkbite-impression of the complete upper and lower arches in occlusion. The records were made in a single impression step with the full arch checkbite-impression tray, and transferred by the face-bow from the patient to the articulator.

in a way never before possible, in transferring work in progress, and in recording before-and-after tooth relations.

The full arch tray can be fitted with recording devices from the simple face-bow to more complicated instruments. This procedure will record a correct centric checkbite, or a premature or accommodative occlusion in proper relationship to the skull for transfer to an articulator. Study of eccentric checkbites and their transfer to an articulator for adjustment of the articulator is possible.

SUMMARY

1. The acceptable accuracy of reversible hydrocolloid for crown, bridge and inlay impressions is recognized.

2. The accuracy of alginates for the same purpose is questioned.

3. The available die materials are adequate, but should be improved since they are not perfect.

4. Various techniques for the use of the unilateral checkbite-impression tray are described. These include: making a checkbite at the same time the impressions of preparations for single or multiple inlays, three-quarter and full crowns and the edentulous areas for a bridge are made; making a simple checkbite in alginate to be used with dies for inlays and crowns which have been made from separate impressions; recording the correct relations of the parts of a bridge to opposing and adjacent teeth for bridge repairs, and making one piece cast bridges.

5. The anterior checkbite-impression tray and its uses have been described.

6. The full arch checkbite-impression tray for making simultaneous impressions of both arches at the same time the centric jaw relations are recorded has been described. This tray may be used in conjunction with other recording equipment for making casts and mountings for the study of occlusal relations in the various jaw positions. It may also be used for restorative procedures which are being done simultaneously in both arches.

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OPERATIVE PROCEDURE FOR GOLD INLAYS

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SO MUCH has been said and written on the subject of gold inlays that it would be presumptious to think that one could add anything new. However, there are some essentials in the complete procedure which are so important for success that perhaps it will be of some benefit to review and reconsider them. It is, therefore, the intent of this paper to summarize, rather briefly, salient factors in refined operative procedure, particularly as they apply to the restoration of lost tooth structure with gold inlays.

The gold inlay is generally recognized as being, potentially, one of the superior restorations in dentistry. The qualifying term—potentially—is necessary. Unless the entire procedure, from cavity preparation through to the final finishing of the margins of the cemented casting, is conducted carefully and with exactitude, the gold inlay can be one of the worst nostrums at the disposal of the dentist. The fact that a tooth carries an inlay so often seems to clear it of suspicion of further break-down; yet if the cavity has not been properly prepared, if all caries has not been removed, if an exact, closely fitted casting has not been made, or if even a good casting has not been properly cemented in a clean, dry cavity and the margins definitely finished—then service to the patient has not been discharged properly.

Why is it that so many inlays fail? Surely not from a purposeful shoddiness of technique, or lack of desire to place fine restorations. Nor is it because of any dearth of adequate means to produce accurate castings. Is it not due rather to acquiring gradually a habit of seeking short cuts in procedure to such a degree that minutes are saved at the expense of efficiency? We would not be human if we did not seek easier methods of accomplishing tasks. Yet care must be taken to regularly assess our current techniques in all operative procedures, and to discard any tendency to produce poorer results. Let us conduct such a mental inventory.

DIAGNOSIS

Before commencing any dental operative procedure an accurate diagnosis must be made of prevailing conditions, from which a plan of treatment is determined. All diagnostic facilities should be utilized including verbal, ocular, instrumental, and radiographic.

A reminder with special emphasis is that once a radiograph is made of a tooth, it is not automatically interpreted by a hasty glance at a wet film. Radio-

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graphs must be studied carefully, both with and without magnification. It should be recalled that the amount of destroyed tooth structure is minimized and never exaggerated in an accurate radiograph. The small V-shaped area of decalcification that reaches the dentino-enamel junction, is not just a round superficial spot, but an area as wide as shown in the radiograph and at least two mm. long. When such decalcifications have reached the dentino-enamel junction they should be filled. Do not jeopardize the patient's welfare, or your own professional standing, by ignoring such areas. If they have only partially penetrated the thickness of the enamel, advise the patient of their presence, and be sure that they are kept under periodic radiographic observation. Any other procedure in this day might well be considered criminal negligence.

A tooth must be considered as a unit and also as a component part of the mouth. There is little point in restoring the original form of a tooth which is malposed in the arch, when it might just as readily be made to function by altering its shape to conform to the requirements of the mouth in which it is situated.

Consider also whether the tooth will be better served by including all carious areas in one restoration or if tooth structure may be saved by placing two or more restorations in the one tooth. For example, it is frequently better to make separate restorations when both mesial and distal surfaces are involved in the upper first molar, lower first molar, and lower first bicuspid.

ANESTHESIA

After fixing upon the course of treatment, and in this instance, a gold inlay being the choice of restoration, the first step in actual procedure is to secure adequate anesthesia of the parts to be worked upon. There is no good reason why any and all dental procedures should not be painless. The percentage of cases is negligible in which anesthesia will not be a distinct boon to both patient and dentist. With simplified, proper armamentarium and technique, there should be no discomfort to the patient either during or after the procedure. In most cases local anesthesia permits more care and attention to detail than does analgesia. Sharpen needles after each use, and insert them gently into stretched, low-sensitivity tissues, which have first been treated with a surface anesthetic, and there will be no objections from the patient. Use alkalinized solution at body temperature, injected very slowly, and there will be no after-soreness. Supraperiosteal infiltration for upper teeth and the four lower incisors, and a mandibular block for lower posterior teeth will simplify technique requirements.

RUBBER DAM

After administering the anesthetic, the teeth to be included in the field of operation should be freed of mucous plaques and calcareous deposits. Not only will a clean field present, but it will avoid the carrying of extraneous material under the free gum margin when applying the rubber dam.

The placing of the rubber dam is the next step in procedure. This is one of the most neglected yet one of the most essential requirements for fine operative technique. Aside from the pleasure for the operator to work in a field that is dry

and clean, free of saliva, wet cotton rolls and a curious tongue, consider the advantages of a rubber dam. With coordinated effort by the operator and assistant, in only two or three minutes time, a field of operation can be obtained in which the lips and cheeks are retracted and supported, the throat is protected from debris, the tongue is controlled from the standpoint of both vocalizing and inquisitiveness, the free gum tissues are retracted to expose the otherwise inaccessible gingival margin of a cavity, the cavity can be more readily and thoroughly cleaned and sterilized, defects in the tooth structure can be seen which otherwise would escape detection, imperfections in cavity preparation may be seen and corrected, proper conditions of the cavity may be obtained for the placing of the restoration, finishing and polishing of the margins of the filling may be accomplished with more ease and assurance of perfection and with less danger of harming the surrounding gingival tissues. Another "selling-point" for the rubber dam is that with time at a premium, the dam is a definite time-saver as may be simply proved by comparing the few minutes necessary to place one with the countless minutes lost by following the alternative "grind, squirt, and spit" technique.

A simple routine technique, readily acquired, will standardize procedure to such an extent that it becomes second nature to utilize the time between administering the local anesthetic and the onset of effective anesthesia by placing a dam.

CAVITY PREPARATION

With a suitable field obtained, the cavity is prepared. Here again, simplified, standardized procedure is a time saver. There are any number of adequate techniques of instrumentation. Each serves the purpose if the end result is obtained with clean orderly dispatch.

General considerations to be followed are the use of properly made, well-sharpened instruments, new sharp burs, clean true diamond points. Operating in a dry field is to be preferred to keeping water playing over the tooth. An exception to this is the case of reducing the bulk of tooth structure when making a preparation for a full crown, or when clearing the occlusion for any extensive preparation. This is done more effectively under water with diamond or carborundum stones before placing the rubber dam.

Great care should be exercised when working in a dry field not to injure the pulp of the tooth by too industriously subjecting the cavity to unnecessary blasts of air, either cold or hot. Nor should the cavity be so dessicated that even soft carious dentin feels hard under the excavator. To avoid the occurrence of this latter error it should be routine procedure before the toilet of the cavity to apply a drop of moisture to the cavity and then go over the entire surface with a sharp excavator. The picture to be kept in mind while operating a tooth is to strive to keep it as nearly as possible at body temperature and with its normal water content. Thus when large burs or stones are used and more heat generated, more cool air should be used to dissipate the heat; when small burs or hand instruments are being used, intermittent warm air should be applied.

In developing the actual cavity preparation, the histologic structure of the tooth must be kept in mind. No tooth should be operated upon without a radio-

graph. So often pulp chambers are so abnormally large that even the shallowest of cavity preparations will endanger the life of the pulp unless adequate protective measures are taken. Occasionally abnormal pulp recession will leave a horn of the pulp chamber in a location which might be involved in extensive cavity preparation unless the danger is realized. The preparation should be cut with definite straight walls, sharp angles, and a flat base. Undermined and unsupported enamel should be removed. Retention and resistance form should also be definite, but with the strength of the gold alloy in mind, less bulk is necessary and consequently less tooth structure needs to be removed. Recall also that too much gold does nothing to enhance beauty, and confine visible margins as much as is consistent with the principle of extension to immune areas. Lightly cove or round the axio-pulpal line angles to strengthen the casting. Carry the gingival bevel around the buccogingival and linguogingival angles, creating a beveled angle in an otherwise vulnerable area.

Undercuts which result from removal of last traces of carious dentin are avoided or eliminated by either leaving the caries till the impression is made, and then removing it completely, or by removing it and filling the undercut so formed by a temporary application of modeling compound until the impression is made, or by filling the area with a mix of oxyphosphate cement in which is incorporated some silver alloy filings, and trimming to final cavity form.

The finish of the cavity walls is best made by a final planing with freshly sharpened instruments, cuttle discs, and fine diamond or carborundum points.

IMPRESSION

The next step in the procedure is the making of the impression, and/or the preparation of the pattern. Dental inlays are so relatively small that even very slight inaccuracies in an impression or pattern produce ill-fitting castings. As has often been said, a casting can be no better than the pattern. Therefore, a technique should be adopted which pays attention to details, and yet is free of superfluous frills. Each step should have a logical explanation. Time is important and should be saved whenever possible through standardization of procedure.

Fundamentally there are three methods of obtaining a pattern: direct, indirect, and indirect-direct. Each has its indications and contra-indications. The method to be the choice for any given case should be determined by a combination of considerations:

1. The ability of the operator with the technique. Some men become so adept with a particular method that they can accomplish results in some cases which would be extremely difficult if not impossible for one who is accustomed to some entirely different procedure.

2. The type of patient. The cooperation of the patient, his outlook on the procedure, and his time schedule, often enter into the picture.

3. The type of cavity and the location of it in the mouth. The extent of destruction of tooth structure, and the location of the tooth in the mouth are predominant factors in determining technique. A cavity of minimal extension, such as a proximal in a bicuspid, can be handled with a direct technique, often with less

cutting of tooth structure than would be possible with the indirect method. On the other hand, extensive destruction of a molar or a preparation extending far gingivally, or a slice preparation, or full cast crown, are examples of cases where only the indirect technique is adequate. The indirect-direct technique can be used in almost any case. Its particular indication however is for complex cavities and occasionally for full cast crowns. For delicate preparations with a slice or pin, or where there is abnormal gingival extension, the disadvantages as a rule outweigh the advantages.

4. The type of assistance available. This factor is a definite consideration. Without a well trained chair assistant using a mouth lamp to provide direct light or transillumination and exercising judicious use of the air syringe, the direct technique is particularly difficult and time consuming if accurate results are to be obtained. Such assistance is, of course, indispensable for any and all dental operative procedures, if they are to be accomplished with care and dispatch, but its absence is felt especially in the direct pattern technique.

The question may be summed up by stating that the operator should be equipped with the necessary knowledge and ability to obtain the impression or pattern by whichever method will best serve the case at hand. However, in the hands of the average man, the indirect technique is preferable in the great percentage of cases, if the wax is to be manipulated with the greatest control of distortion.

If the decision is to make the pattern by the direct technique, it is best done with the dam still in place. If the indirect technique is to be followed the dam is removed before making the impression, but after the copper band has been trimmed and fitted.

TEMPORARY PROTECTION

Before dismissing the patient, the prepared tooth must be adequately protected. This may be done by use of a temporary inlay of low fusing base alloy, a temporary cement, or baseplate gutta-percha. For anterior three-quarter crowns or where the temporary protection must be in for some time, the temporary metal inlay is the method of choice and is quickly made. For deep cavities or where the outer circumference of the tooth is involved one of the temporary cements having a zinc oxide base, either alone or in conjunction with a copper or aluminum band, is preferred. In the cavity of average depth in which protection is required for a short interval, baseplate gutta-percha gives good protection. It may be manipulated at a tolerable temperature to the tooth by dipping in eucalyptol. It is much more satisfactory than temporary stopping. Of course care must be taken not to let it impinge upon the soft tissues, nor to leave it in supra-occlusion or a tender tooth will result.

PRELIMINARY ATTENTION TO THE CASTING

Preliminary attention to the casting before fitting it at the second appointment includes preliminary finishing of the external surface; also a close inspection of the cavo-surface for nodules which are often present even though microscopic in size.

The next step is to create space for the cementing medium. This is done either by etching the cavo-surface of the inlay to within 1 mm. of the margins with aqua regia, or by grinding lightly the axial and pulpal surfaces of the inlay. It is an essential step for, otherwise, if the casting is accurate and close fitting as it should be, then interposing a layer of cement will preclude seating the inlay completely to place, and further a valuable means of pulp protection against thermal shock would be lost.

INSERTION AND FINISH

At the second appointment, if the tooth is particularly sensitive, local anesthetic is again administered. The temporary protection is removed and the cavity carefully inspected for any remaining debris. The inlay is then fitted. Contact points are adjusted. The accuracy of the fit is closely checked, particularly at the gingival margins by the aid of a mouth lamp. If by chance it is a misfit, discard it and make a new inlay. The patient will think more of the man who is honest, and the operator will have a higher self regard if mistakes are admitted. The man who *never* has to remake an inlay doesn't make many or is not sufficiently awake to human limitations to be an operator in whom one can have a great deal of confidence. If there is any doubt as to the fit of the casting, take a bitewing radiograph of it in place before cementing. By the use of a rapid-processing film or rapid developer, a quick check may thus be made, and a *future* makeover avoided. When the casting has been accepted for fit, occlusion is checked and corrected if necessary. Margins are then dressed down with fine stones, discs, inlay finishing burs, and files. The inlay is then removed, occlusal and peripheral anatomy is completed and the surfaces polished thoroughly and carefully. The assistant keeping a blast of cold air on the casting at this stage greatly reduces the time element. The inlay is then cleansed of all debris by brushing with soap and water and dried.

The rubber dam is then applied and while the final toilet of the cavity is being made, the assistant completes the preparation of the casting for cementation. This consists of going over the inlay with a cotton pellet and carbon tetrachloride to remove any traces of grease or oil or polish; and then applying a thin film of petroleum jelly over the outer surface, keeping well away from the margins.

To complete the preparation of the tooth to receive the inlay after the dam is placed, a definitely planned procedure must be carried out. The following is offered as one which has given satisfactory results for a number of years. The cavity is flooded with a fresh mixture of five drops of hydrogen peroxide and one drop of household ammonia. If it is passed through a flame before being carried to the tooth, thermal shock will be avoided. The effervescence of this alkaline mixture loosens debris in the cavity. The cavity is wiped dry. This is followed with a pellet full of warm water. Again the cavity is dried and the entire surface gone over carefully with an excavator to assure removal of any carious or extraneous material. The cavity surface is then sterilized in so far as that is possible, by the application of an effective chemical agent such as melted thymol crystals, phenol, or beechwood creosote. This is dried into the dentin with warm air. If any of the

margins have been contacted, wipe them carefully with carbon tetrachloride. The procedure now depends upon the depth of the cavity. If it is of minimal depth no further treatment is necessary. If somewhat deeper a cavity varnish may be applied to the deeper portion. If there is a great deal of dentinal destruction, a base of a heavy paste of zinc oxide seven parts with thymol iodide one part, mixed with eugenol, may be placed in the deep portion. The cavity is now ready to receive the casting.

The cement of choice is placed upon a cool slab, and about two minutes prior to the time of its anticipated need, a portion of powder the size of an apple seed is incorporated into the liquid. This procedure produces a delayed setting time and enables a heavier mix of cement to be used than would otherwise be possible. The cement when mixed to the desired consistency is carried to the cavity with a fine instrument, care being taken that cement is conveyed to the depth of all pin-holes and angles without trapping any air. Cement is also flowed over the entire cavo-surface of the casting, which is then carried to the cavity and pressed home. Final seating is accomplished by heavy hand pressure with an orangewood stick assisted by light blows from a mallet in the hand of the assistant. Pressure should be heavy and sustained until the initial set of the cement is complete. While the pressure is maintained the margins are spun out by the use of a rounded hand instrument such as a Gillett spinning instrument, or a burnisher, to eliminate even a film thickness of cement on the surface.

When the cement has set, the petroleum jelly on the surface of the inlay permits the excess cement to be flicked off with very little marring of the inlay surface. All margins are carefully checked and finished with extra fine cuttle discs and strips. The dam is removed and final polishing is done with a paste of lap emery, and finally with a dry final polish carried on rubber cups and mounted brushes in the handpiece. The tissues are then transilluminated with a mouth lamp, and a fine explorer is used to be sure that no particles of cement or polishing material have been worked under the free gum margin. The operation may then be considered completed.

CONCLUSION

In this over-all recapitulation, an attempt has been made to stress two cardinal points. First, the need for the acquisition and practice of simplified procedures which are standardized as much as possible for each operation of similar type, so as to eliminate wasted time and effort. Secondly, the insistence on attention to detail from start to finish, for carelessness in just one step in a procedure will endanger the end result. And so it is repeated that in fine operative dentistry, the the patient and the profession will be served as they deserve only by striving toward the ideal of perfection in each and every operation.

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INFLUENCE OF MIXING TECHNIQUES ON SOME PHYSICAL PROPERTIES OF PLASTER

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THE EVER-increasing usage of vacuum equipment and power-driven mechanical spatulators prompted this investigation relative to the effects of such manipulation on the physical properties of dental plaster. The ultimate objective was to determine what type of procedure would produce optimum physical properties.

Studies previously done on plaster of Paris have revealed much concerning its basic physical properties. Factors such as water-plaster ratio, setting time, dimentional change and the use of accelerators and retarders have been thoroughly studied by Kimball, Rice, Worner, and others.[1-7] However, relatively little work has been done on the effects of the newer manipulative techniques. The purpose of this investigation, therefore, was to compare the properties obtained from these procedures with those secured by conventional hand techniques.

PROCEDURE

One commercial plaster, Kerr No. 1, was used throughout this study, and a water-plaster ratio of 1:2 by weight was employed. Three basic general methods of preparing the plaster mixes, all in common usage, were studied: (a) spatulation by hand, (b) spatulation by hand plus the auxiliary use of vacuum, and (c) power-driven mechanical spatulation. In addition two other factors included were: (1) method of adding plaster to the water, (2) type of equipment used in hand technique, i.e., comparison of a rubber bowl and spatula with a rigid glass bowl and a spoon.

The specific techniques employed for each procedure were as follows:

A. *Hand Spatulation.*—Four distinct groups were established and the procedures are summarized in Table I.

In *Group 1* a glass bowl and spoon were used and the plaster was carefully sifted into the water with a flour sifter, two and one-half minutes being required to bring the two into solution. No mixing was done until this was accomplished. The plaster was then carefully spatulated with a round soup spoon for two and one-half minutes using a wiping motion of the spoon against the sides of the bowl. This particular procedure is widely used for making orthodontic casts.

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In *Group 2* the same technique was used as that for Group 1, except that a rubber bowl and spatula were employed instead of a glass bowl and spoon.

In *Group 3* a glass bowl and spoon were again used, but the plaster was quickly dumped into the water, throughout a period of forty-five seconds. The mix was then spatulated with a rapid whipping motion for one and one-half minutes.

In *Group 4* the same technique as that for Group 3 was employed, except that a rubber bowl and spatula were used instead of the glass bowl and spoon.

The mixing time for the groups where the plaster was dumped in was one minute less than that when sifted. The reason for the difference was due to the fact that a more vigorous whipping motion was employed, and thus mixing was accomplished more rapidly.

The mixing times for these various groups were arbitrarily selected but were based upon sound and accepted dental techniques.

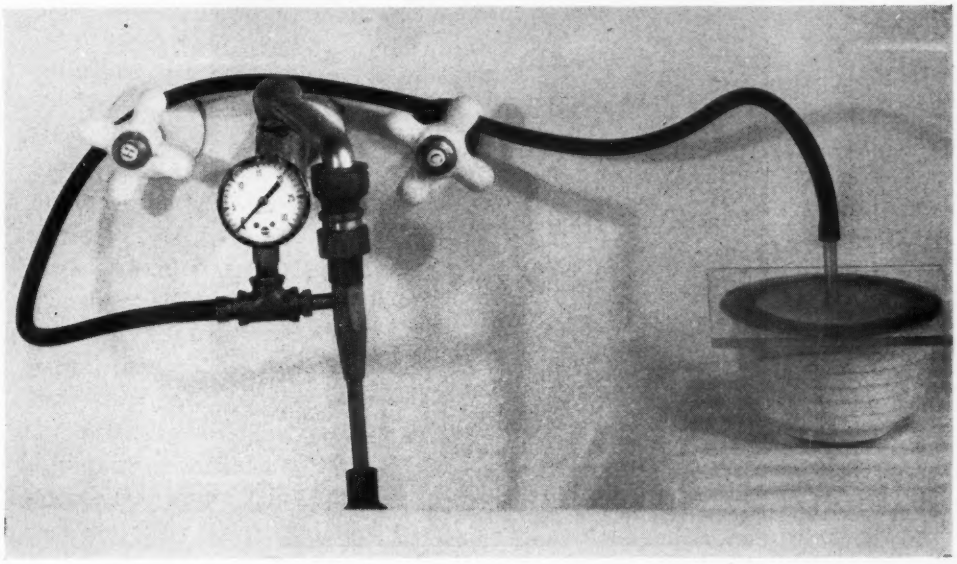

Fig. 1.—Vacuum equipment used in this investigation.

As a basis for comparison, *Group* 5 tests were also made on specimens prepared by a careless hand technique where both the water-plaster ratio and time of spatulation were guessed. A rapid whipping motion was also employed for these mixes. This technique was included because it is believed to be the one in most common use by dental practitioners.

B. *Vacuum Technique.*—Mixes prepared by the technique described above in *Groups* 1 and 3 were subjected to vacuum before pouring. Equipment used to create the vacuum was devised by the authors and makes use of the water-aspirator principle. Fig. 1 illustrates the apparatus. Twenty-eight inches of vacuum are obtained from the filter pump type of aspirator wherever the water pressure is 30 pounds or more. As can be seen, the mix is vacuumed by placing a plastic cover

over the bowl. A tube is incorporated into the cover which connects to the source of vacuum by means of a rubber hose. A rubber gasket provides a seal between the cover and the bowl. The mixed plaster was subjected to vacuum for one minute, and during this evacuation period the mixing bowl was placed on a dental vibrator.

Other equipment is, of course, available for vacuuming mixes of plaster, but this type seems to be equally efficient, is inexpensive and practical, and its applications are many.

Fig. 2.—Power-driven spatulator.

C. *Power-Driven Spatulation.*—Fig. 2 illustrates the type of equipment used for the mixes made by this method. Again, there are various other types of spatulators available, but this particular model seems to be representative. The plaster was sifted into the rubber bowl, two and one-half minutes being required to bring the plaster into solution. The mix was then hand spatulated for a few seconds before being placed into the mechanical spatulator where it was spatulated for one minute. Mixing speed of the spatulator was 550 revolutions per minute without load.

PHYSICAL PROPERTIES TESTS

The physical properties tested were compressive strength, porosity, micro- and macro-examination of the cut surfaces. Compressive strength was run on 7-day-old specimens which had been mechanically vibrated into a rubber mold.

TABLE I.

HAND	EQUIPMENT	METHOD OF ADDING PLASTER	MIXING TIME
Group 1	Glass bowl and spoon	Sift—2½ min.	2½ min.
Group 2	Rubber bowl and spatula	Sift—2½ min.	2½ min.
Group 3	Glass bowl and spoon	Dump—45 sec.	1½ min.
Group 4	Rubber bowl and spatula	Dump—45 sec.	1½ min.
Group 5	Uncontrolled		

The specimens were 1.3 inches in diameter and 2 inches high. They were stored in air at room temperature before testing. The load was applied at the rate of 650 pounds per minute by means of a Tinius Olsen machine. A minimum of twelve specimens was made for each series.

Porosity was determined by a wet-flow meter, measuring the flow of air in cubic feet per minute through a plug of plaster. The specimens were seven days old and the air going into the mold was held under a constant pressure of 20 pounds. The figures shown in this paper are the averages of at least four individual specimens.

In order to detect visually any bubbles and porosity within the mass of plaster, large plaster molds approximately 4¼ inches by 3 inches by ⅝ inches were prepared. After the plaster had set for one week, the molds were sectioned by grinding from the top and bottom. This left only a center section, 5/16 inches thick, to be used for examination. This sectioning was carried out first with a model trimmer and followed by careful planning with fine carborundum stones. The final surface was then prepared by an Arkansas stone. The surface was photographed under standard lighting conditions to show the gross porosity. They were also studied under 3× magnification. It was felt that obtaining a cross section from the middle of the mold would be more indicative of the true porosity throughout than merely examining the outer surface. Special care was taken during the sectioning to prevent any filling of the porous areas. These visual and microscopic examinations were deemed essential in order to detect the actual magnitude and distribution of porosity. From the orthodontist's standpoint, porosity is undesirable for esthetic reasons which require filling in all holes. In prosthetics, porosity in the plaster mix may manifest itself in the form of actual nodules on the acrylic surface.

TABLE II

TECHNIQUE	DENSITY RESULTS WET-FLO-METER ($FT.^3$ / MIN.)	COMPRESSIVE STRENGTH (LBS. / $IN.^2$)
Hand-sift-glass bowl	.060	4244
Hand-sift-rubber bowl	.022	4123
Hand-dump-glass bowl	.046	4184
Hand-dump-rubber bowl	.072	3980
Mechanical spatulator	.025	4595
Hand-sift-glass bowl-vacuum	.061	4429
Hand-dump-glass bowl-vacuum	.055	4499
Uncontrolled	.154	2122

RESULTS

Generally there was little difference in the porosity measurements, as shown in Table II. The higher the figure, the more porous is the sample. It is possible, however, to point out a few significant observations. The results of mechanical spatulation indicated a general increase in density as seen by the small amount of air passing through the specimen. (It should be remembered that the term

Fig. 3.

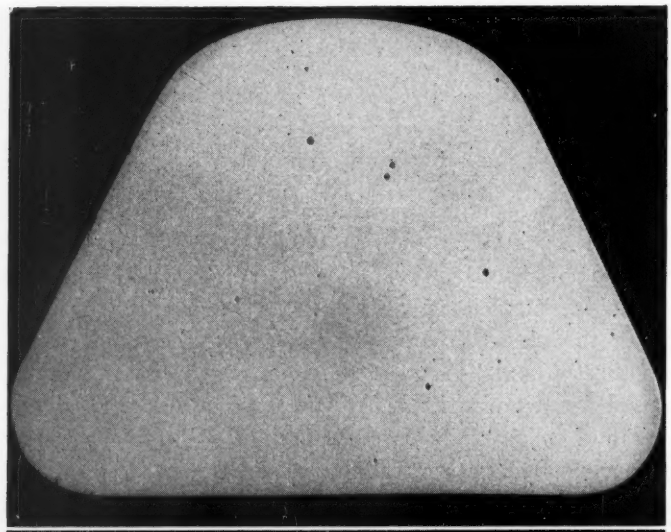

Fig. 4.

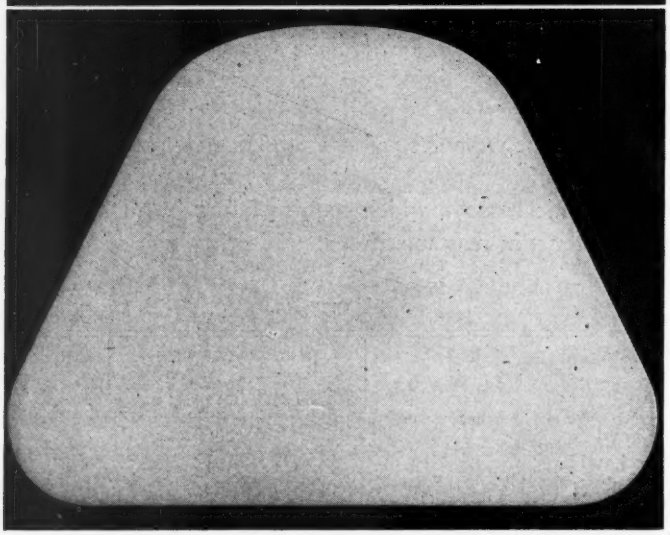

Fig. 3.—Plaster surface of specimen prepared by sifting powder and mixing in glass bowl with spoon.

Fig. 4.—Mix prepared by sifting powder and mixing in rubber bowl.

density used here merely reflects the porosity of the specimen and is not used in the true physical sense of mass per unit volume.) The individual data on these samples were also quite constant, indicating a uniformity of mixes. Another low value will be noted for the sifting technique in a rubber bowl. There is no obvious explanation why this technique yielded better results than the same procedure carried out in a glass bowl. The highest measurement, of course, resulted from the uncontrolled technique where the air flow through the specimen was extremely

Fig. 5.

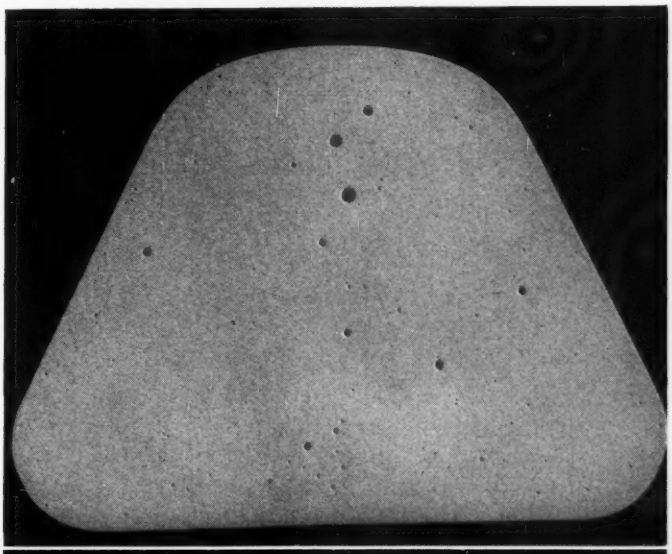

Fig. 6.

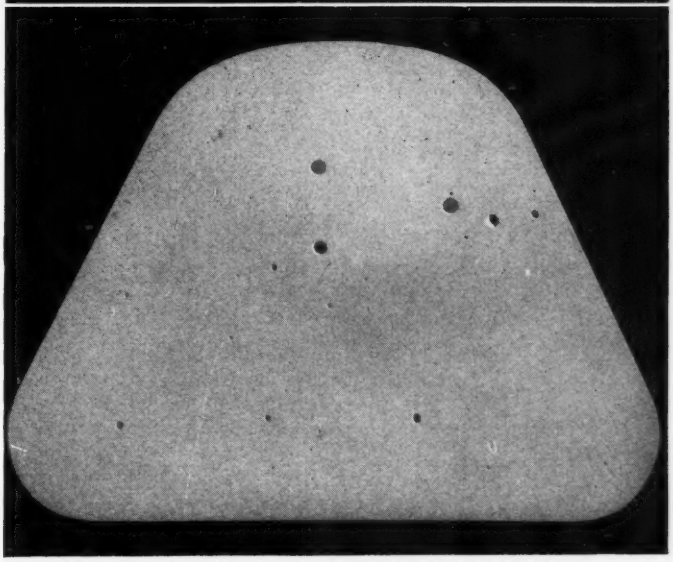

Fig. 5.—Paster dumped in and mixed in glass bowl.
Fig. 6—Plaster dumped in and mixed in rubber bowl.

great. The remainder of the data falls within the experimental error for this type of test.

Compressive strengths are shown in Table II. Again the results were fairly uniform. Actually, the differences are not sufficient to be of practical significance, except for the uncontrolled technique. Looking at the hand technique, it can be seen that where the plaster was sifted into the water, the results are slightly higher than when it was dumped. Vacuuming a mix also yielded a slight increase in

Fig. 7.

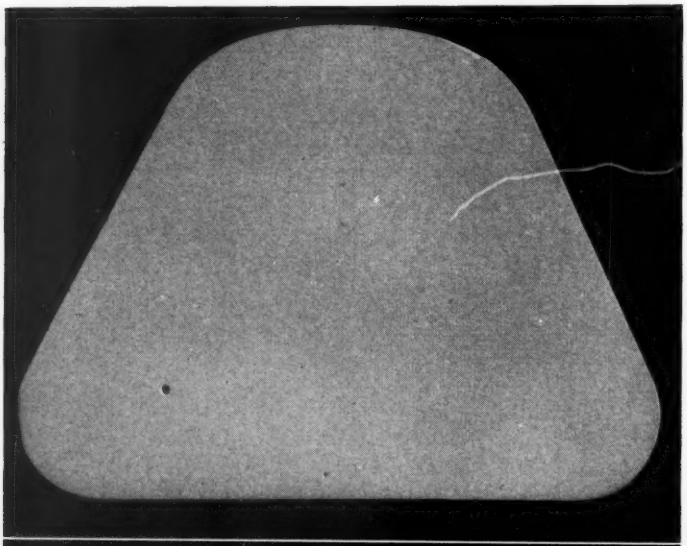

Fig. 8.

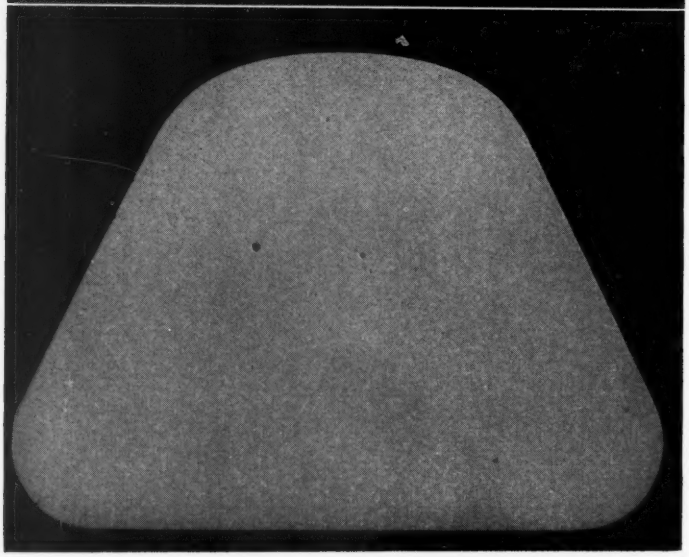

Fig. 7.—Plaster sifted in and mix then vacuumed.
Fig. 8.—Plaster dumped in and mix vacuumed.

strength, when the plaster was either dumped or sifted in. The fact that vacuum does reduce the porosity and thus increase the strength of investment has been demonstrated by Ireland[8] and Phillips[9]. Mechanical spatulation undoubtedly results in the most thorough mixing, as shown by the high strength data. The uncontrolled technique again yielded definitely inferior results. The strength was 50 per cent less than that for any other procedure.

Fig. 9.

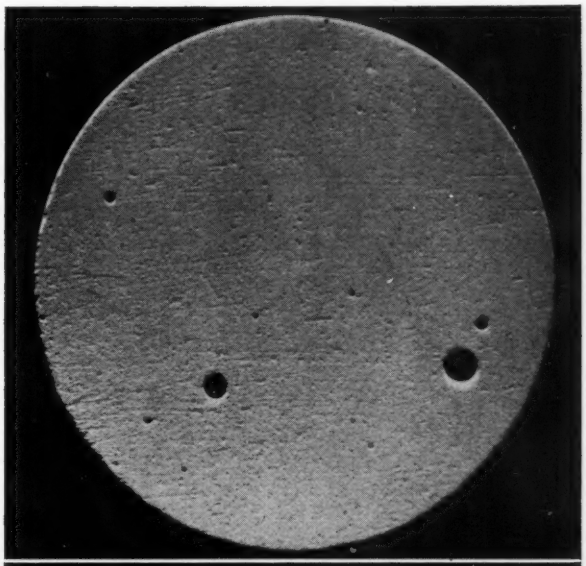

Fig. 10.

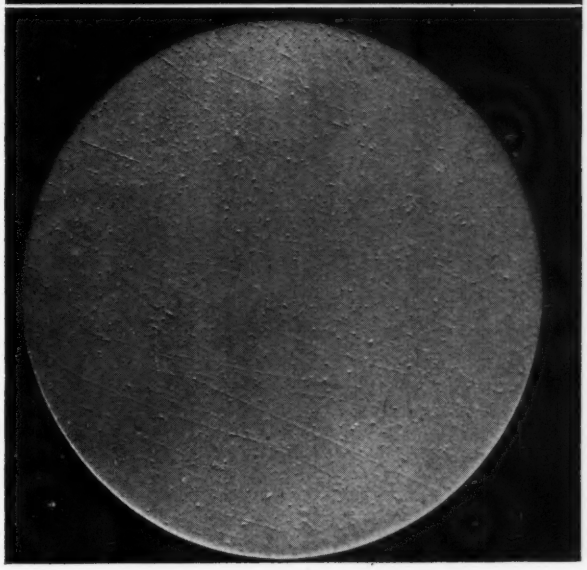

Fig. 9.—Magnification (3×) of surface shown in Fig. 5.
Fig. 10.—Magnification (3×) of surface shown in Fig. 8. Vacuum has reduced air voids.

Although the results on the porosity measurements and compressive strengths were generally quite close with the various techniques, some definite differences were detected when the actual plaster surfaces were studied. Photographs of the gross specimens are almost self-explanatory, and representative specimens are shown. Fig. 3 compares the glass bowl, using the previously described sifting technique, with the same technique in a rubber bowl (Fig. 4). These specimens show the surface is slightly superior when mixing is carried out in the rubber bowl rather than in a glass bowl. This substantiates the data obtained with the measurements made on porosity.

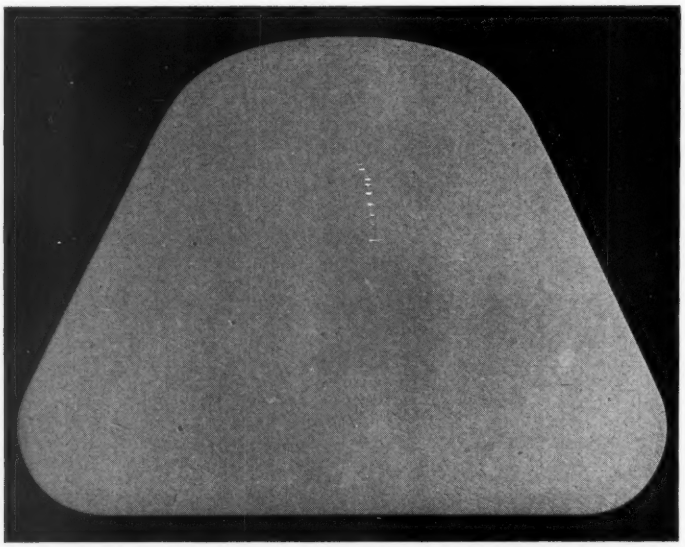

Fig. 11.—Surface produced by power-driven spatulator.

Comparing the two types of bowls again, the next photographs depict the results of dumping the plaster in, first in the glass bowl (Fig. 5) and then the rubber bowl (Fig. 6). Superiority of the rubber bowl is not so evident here. However, both specimens are definitely more porous than when a sifting technique was employed. It would be expected that more air would be carried into and retained by a technique where the plaster was not sifted in. A sifting technique, actually using a flour sifter, has long been advocated as the preferred method of adding plaster to the water.

The type of specimen produced sifting the powder in and then vacuuming the mix can be seen in Fig. 7. Results of this technique are quite striking. For further comparison of vacuum, the procedure of dumping the plaster into a glass bowl is repeated (Fig. 8). Here again the results are significant. The reduction in surface porosity by vacuuming the mix is further illustrated in higher magnification of these same surfaces. Fig. 9 shows the dumping technique in a glass bowl compared with the same technique after having been vacuumed (Fig. 10).

Perhaps the most consistent results were obtained from the power-driven mechanical spatulator. Fig. 11 shows the surface obtained. It can be seen that the principal difference between the mechanical spatulator and vacuum is in the absence of large bubbles in the mechanical mix. Any porosity is in the form of smaller bubbles. Vacuuming, as shown, does reduce the number of small bubbles but does not eliminate all of the large ones as is the tendency with mechanical

Fig. 12.

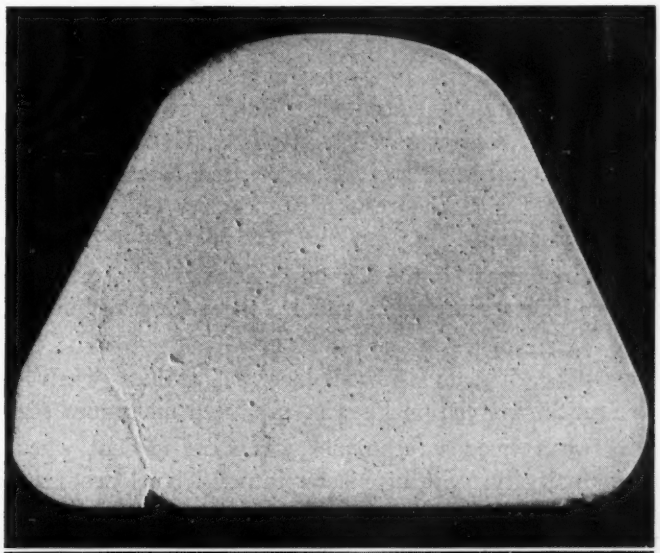

Fig. 13.

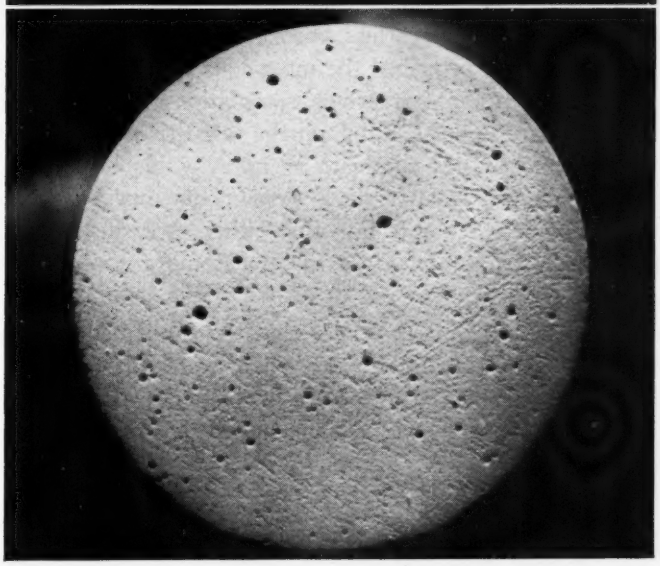

Fig. 12.—Uncontrolled technique produces inferior surface.
Fig. 13.—Magnification of surface shown in Fig. 13.

spatulation. Mechanical spatulation breaks down the air bubbles to such a small size that they are not readily apparent under ordinary circumstances.

The last two photographs (Figs. 12 and 13) concern the uncontrolled average technique and are a vivid reminder of the value of using a standardized procedure.

Further studies are now in progress which will include the use of hand and motor shakers.

CONCLUSIONS

It should be pointed out that all the techniques used in this study, except the uncontrolled one, were carefully executed. Water-powder ratios, mixing times, incorporation of powder, etc., were all controlled. Even when the plaster was dumped into the water, forty-five seconds were used to carry out the procedure. It is not surprising then that the results on porosity and compressive strength did not show greater variations.

Less porosity, measured by the air flow meter, was obtained on specimens prepared by power-driven spatulation and by the sifting technique in a rubber bowl.

Compressive strength data showed increased values when the mix was vacuumed. Mechanical spatulation likewise produced maximum strength.

Difference between various techniques was most evident when cut surfaces were examined for porosity. Sifting plaster into the bowl produced less porosity than dumping; vacuuming significantly reduced air voids with either procedure. Apparently the rubber bowl, being flexible, results in slightly better spatulation than the glass bowl and thus gives less porosity. The power-driven mechanical spatulator used in this study produced the most consistent results. The main difference between vacuum and power-driven spatulation seems to be that vacuum does reduce the number of bubbles, although the few that remain are rather large. Mechanical spatulation does not eliminate as many voids but those that remain are broken down to a much smaller size. Arguments may be presented for the advantage of each, but it was our feeling that either procedure produces superior results and mechanical spatulation gives somewhat more consistent and uniform gross surfaces.

Results obtained here again emphasize that the fundamentals involved in the use of plaster cannot be violated. In particular, water-plaster ratio and proper mixing procedure must be adhered to. Data in this study show the inferior properties present when the plaster technique is uncontrolled.

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Indianapolis, Ind.

Book Review

THE PORCELAIN JACKET CROWN, By S. Charles Brecker, D.D.S. 263 pages, with 290 illustrations and frontispiece in color. Indexed. St. Louis, The C. V. Mosby Company, 1951. Price $8.00.

This is the first piece of dental literature with a new approach to the preparation of teeth for porcelain jacket crowns. It demonstrates clinically that preparations are not the same for all teeth. Doctor Brecker is the first to present a guide for management of jacket crowns influenced by the anatomy, the condition, and the position of the teeth. "Rarely are we called upon to prepare an ideal tooth," and so the author introduces a practical classification of preparations for all types of teeth. He writes, "Most advocated methods seem ideal when illustrated and described on a model, but are impractical to execute on a tooth in the mouth." With practical application in mind, I have endeavored to describe the convenient finger positions, instrument grasps, and stones used in sequence that will aid the general practitioner and undergraduate student in the procedures."

This clearly printed manual answers a problem which is becoming increasingly more important in everyday dental practice. In Chapter 3 the author describes the preparation of teeth heretofore considered perplexing problems such as the pointed canine, teeth with marked constriction on one surface, thin delicate tooth, short broad incisors, and many others. "The anatomical shape of a tooth influences the preparation to such a degree that it would be impractical to create a complete shoulder of uniform width." Doctor Brecker describes the technique for preparations with full shoulders, partial shoulders, and shoulderless borders.

In Chapters 4 and 5 there are the same lucid instructions for the treatment of nonvital teeth, the overlapped tooth, the protruding tooth, and the one in lingual position. Of particular interest to those doing extensive oral rehabilitation cases is the chapter on the correction of objectionably spaced teeth in adults by ceramic means. For the first time, a definite treatment plan to improve the esthetics of wide diastemas, spaces caused by migration, etc., is brought to our attention in a clear and precise manner, backed by practical case reports.

Book reviewers are in accord as to the original and practical contribution this text has made. Dr. Frank P. Lindner, of Loyola University[1], writes, ". . . I was particularly interested in his classification of preparations. It is provocative. Perhaps it can cause a thought or two in dealing with our particular jacket preparations. I felt that his essential procedures in the preparation of jacket crowns thoroughly covers a mental armamentarium for us. I recommend that it be read and reread. The author carefully illustrates the technique peculiar to the preparation and variations encountered in each of the teeth in the arch, the rest position, and the instrumentation involved. I think the book is one that is scientific, well written, easily understood, very inclusive and worthy of consideration as an addition to our libraries."

Dr. Harold W. Oppice[2] writes, "Doctor Brecker has provided a most useful teaching manual on the subject of the porcelain jacket crown . . . The first five of the manual's eight chapters are largely devoted to verbal and photographic description of the author's step by step technique of preparing any tooth . . . whether of normal or abnormal form, condition or position in the mouth . . . for a porcelain jacket crown."

Chapter 6 is devoted to procedures for taking the impression, the shade, postoperative care, and the final cementation of the crown. Of particular interest is the chapter on the "shortcomings" of this type of restoration, how to prevent or minimize them. We all have been concerned

at one time or another with the red inflamed gum surrounding the neck of the porcelain crown several months after insertion, or the blue discolorations in the gingival area of the restoration. The author describes the reasons for gingival irritations due to overextension, to overhanging collars of copings, to overcontour, etc. Doctor Brecker present his analysis of the reasons why porcelain jacket crowns fracture and lists and illustrates these reasons.

A study of this book will reduce the working time of the operator and simplify the problems that are associated with the treatment of the porcelain jacket crown. This is a must for every general practitioner.

I. Franklin Miller,
412 Medical Arts Bldg.
Pittsburgh, Pa.

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ANNOUNCING

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Dr. Carl O. Boucher, College of Dentistry, Ohio State University,

Columbus 10, Ohio

All contest papers will be sent by him to the committee judging the contest.

Readers' Round Table

Veterans Administration Hospital
Lyons, N. J.

Editor, Journal of Prosthetic Dentistry,

I have waited patiently for the publication of a refutation of Craddock's articles in the J.A.D.A. **38**:697, 1949, and the J. PROS. DEN. **2**:633, 1952, in which attempts to prove the use of protrusive records and face-bow mountings are futile, if harmless procedures. Although I assume the nonappearance of such a refutation is the result of indifference on the part of our outstanding prosthodontists, still the need to record opposition to such recommendations to discard tested and accepted procedures remains.

Because it is so easy to quote the literature by taking a few sentences out of context to prove a point, even though the original authors may be in violent disagreement with the thesis presented, it would appear desirable that the basis upon which Craddock's theories are refuted be found within his articles. Craddock himself used the literature in this manner, when he quoted Stansbery to show that the face-bow is useless, yet the Stansbery technique is based upon precise plaster records of lateral and protrusive jaw relations for articulator settings, a procedure which Craddock also states is useless.

Craddock accepts the concepts of Bonwill in relation to the location of the casts in space between the bows of the articulator and in relation to the opening hinge axis. Then he recommends all cases be mounted in an average relationship (J. PROS. DEN. p. 635). Such a procedure may be considered no more acceptable than one using an average intermaxillary space. Throughout Craddock's article, he considers the effect of a fairly severe error in relation between the casts and the opening axis or condyle. In each illustrated instance, he projects geometrically the degree of grinding required to compensate for the error. Each instance illustrates an error produced in a single plane. He does not consider the cumulative effect of multiple errors in all planes. Rather than his 2 cm. error in one plane, which is in fact an unlikely error, he should have presented, if possible, the geometric equation involved in correcting a 5 mm. error in each of the three planes. If, for example, a case were to be mounted 5 mm. interiorly, 5 mm. too high, with the plane of orientation depressed 5 mm. posteriorly, and with the casts 5 mm. lateral to their anatomic positions, would the grinding or the geometric equation appear so simple? It is known that inclination of the condylar guidance on the articulator decreases when the casts are mounted above their true relationship to the condyle, yet he apparently recommends an average condylar guidance of 35 degrees.

Craddock's suggestion that these "minor" errors are susceptible to correction by spot grinding in the mouth is equally unacceptable. Almost all conscientious prosthodontists who have experimented with spot grinding in the mouth have become convinced that errors are multiplied rather than corrected by such a procedure. Articulating paper prints appear on surfaces not in contact. They appear on cusps, slopes and fossae in centric occlusion, as well as in protrusive or lateral excursions; and differentiation, even with multicolored papers, is difficult or impossible. Corrective grinding or equilibration may be done with much greater facility and accuracy upon an articulator, but unless the cast relationships to the movement axes and to each other are reasonably accurate, errors are repeated.

In conclusion, it may be said that the tendency to eliminate procedures that contribute to the accuracy of the end result, merely because they are time consuming, is an undesirable one. Craddock's conclusions may be paraphrased thusly: "You probably can do almost as well without a face-bow as you can with it, provided you can spot grind accurately in the mouth." Such a tenuous condemnation of a procedure, the accuracy of which is not challenged, does a disservice to dentistry and to prosthodontists.

Very truly yours,

ELMAR A. SIEGEL, D.D.S.

News and Notes

ANNOUNCEMENTS

The Academy of Denture Prosthetics will hold its annual meeting at the Ambassador Hotel in Los Angeles, Calif., on April 13 to 17, 1953.

The Pacific Coast Society of Prosthodontists will hold its annual meeting at the New Miramar Hotel at Santa Monica, Calif., on April 18 and 19, 1953.

The American Association for Cleft Palate Rehabilitation will hold its eleventh annual meeting on April 26 to 28, 1953, at the Atlanta Biltmore Hotel, Atlanta, Ga. The program will be of interest to prosthodontists, orthodontists, speech pathologists, plastic surgeons and pediatricians. For further information write to Dr. Willard T. Hunnicutt, Medical Arts Bldg., Atlanta, Ga.

The Department of Denture Prosthesis of New York University announces short courses in Complete Dentures and Partial Dentures to be given June 1 through June 12, 1953. Both courses consist of lectures, clinical demonstrations and the construction of dentures by each registrant in the class. For further information write to Dr. Raymond J. Nagle, Dean, New York University, College of Dentistry, 209 East Twenty-third St., New York 10, N. Y.

Tufts College Dental School announces a full-time postgraduate course in Prosthetics under the direction of Professor Irving R. Hardy. This course will consist of didactic instruction, clinical demonstrations, and practical work by the participants in full and partial denture prosthesis. Class is limited to six. Applications are now being accepted for the school year beginning October, 1953 through June, 1954. For further information and application write the Director of graduate and postgraduate studies, Tufts College Dental School, 136 Harrison Avenue, Boston, Mass.

Tufts College Dental School announces the appointment of Dr. Louis Alexander Cohn of New York City as Associate Professor in postgraduate prosthetics. In this capacity, Dr. Cohn has initiated a postgraduate course in occluso-rehabilitation which is conducted for two days on alternate weeks through the school year.

This course consists of didactic instruction, clinical demonstration, and practice upon patients. Enrollment is limited to twelve. In addition to his new position at Tufts College Dental School, Dr. Cohn will continue his teaching activities at Columbia University School of Dental and Oral Surgery.

The faculty for the postgraduate course on Functional Occlusion of the Teeth at Northwestern University Dental School will include two distinguished dentists from Sweden, Dr. Henry Beyron and Dr. Gösta Lindblom, who have made important contributions in this field. The course, which is scheduled at Northwestern University Dental School on April 1, 2, and 3, 1953, is arranged expressly for the dentist in general practice who is interested in the practical aspects of the most recent studies of functional occlusion. Enrollment will be definitely limited.

In addition to the foreign participants, the faculty will consist of Dr. Ernest Granger of Mt. Vernon, New York, Dr. Harry Sicher of the faculty of Loyola University School of Dentistry, and Dr. Stanley C. Harris and Dr. John R. Thompson of the faculty of Northwestern University Dental School. The tuition fee for the course will be $100.00.

For further information and application forms write to The Dean, Northwestern University Dental School, 311 East Chicago Avenue, Chicago 11, Ill.

Columbia University School of Dental and Oral Surgery announces a course on the Principles of Occlusion, P. D. 429, to be given on April 8, 9, and 10, 1953, by Professor Lewis Fox and his associates. The course is directed toward correlating the principles of occlusion to clinical criteria and therapeutic endeavors. The fee is $150.00. Applications will not be accepted after March 20. For further information write to Dr. Barnet M. Levy, Director, Postgraduate Division, School of Dental and Oral Surgery, Columbia University, 630 West 168th Street. New York 32, N. Y.

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Textbook of

FUNCTIONAL JAW ORTHOPAEDICS

By

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408 pages, with 536 illustrations or 309 figures. Price, cloth, $12.00

IN THIS textbook on Functional Jaw Orthopaedics the authors have endeavored to present an up to date view of the theoretical basis and the practical aspects of functional orthodontic therapy. The latter aims at bringing about, as far as is possible, the necessary tissue changes by means of functional stimulation. In addition, the book covers the use of active removable appliances such as were developed by A. M. Schwarz.

In the chapter on Aetiology and Diagnosis the authors have tried to survey the views held by all those dental schools which have been primarily responsible for the development of the removable appliance.

Certain methods of diagnostic investigation, of which profile X-ray is an example, could only be dealt with in outline. Views on their value as an aid in prognosis are still too controversial to be included in a book the prime concern of which is with the practical use and scope of the active and removable orthodontic appliance.

In the section on Histology is given an account of the histological investigation of cases treated by functional appliances, together with the results of animal experiments designed to show the influence of function on development. Articular transformation could be given only limited space, but we hope to produce a monograph on the subject in the near future.

A chapter on orthodontic surgery is included, as the authors are of the opinion that the closest co-operation between the plastic surgeon and orthodontist is necessary if the best functional and aesthetic results are to be achieved in those cases which will not respond to conservative orthodontic therapy.

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Hope Renewed

Easter is a time for reaffirming our faith in the future of mankind. As vibrant spring replaces barren winter, as the joy of resurrection triumphs over the darkness of death, so this should be the time when we help implant hope to replace despair in the hearts of the world's unfortunate.

The $10 food package you send through *CARE, 20 Broad Street, New York City*, or your local CARE office, can bring renewed courage to suffering war orphans and refugees in South Korea . . . to impoverished villagers in India . . . to Iron Curtain refugees whose dreams of freedom are mocked by their precarious existence in Western Germany . . . to the weary and worried in a score of countries from Italy to the Philippines. Whatever the language men speak, your CARE gift will be universally understood. It will express your Easter prayer for a world united in peace and brotherhood.